THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

ART. XV.—*Report upon the Results of Microscopic Examinations of the Soundings made by Lieut. Berryman, of the U. S. Navy, on his recent voyages to and from Ireland in the Arctic;* by Prof. J. W. BAILEY, addressed to Lieut. M. F. MAURY, National Observatory.

THE specimens submitted to examination were of two series, viz., those collected on the voyage to Ireland, which will be referred to as series 1, and those made on the return voyage, which form series 2. The specimens of series 1 were from the following localities, viz:*

No.	Latitude.		Longitude.		No.	Latitude.		Longitude.	
1.	47° 50′	North.	52° 00′	West.	13.	52° 24′	North.	29° 16′	West.
2.	48 00	"	51 41	"	14.	52 26	"	27 18	"
3.	48 13	"	51 20	"	15.	52 26	"	26 20	"
4.	40 27	"	50 58	"	16.	52 02	"	24 51	"
5.	48 40	"	50 36	"	17.	51 41	"	22 23	"
6.	48 51	"	50 10	"	18.	51 41	"	21 19	"
7.	50 05	"	40 26	"	19.	51 50	"	20 12	"
8.	50 20	"	38 30	"	20.	52 01	"	17 06	"
9.	50 44	"	37 15	"	21.	52 05	"	16 05	"
10.	51 06	"	35 50	"	22.	52 03	"	15 02	"
11.	51 15	"	34 08	"	23.	51 52	"	13 16	"
12.	51 38	"	32 20	"	24.	51 54	"	12 27	"

* As a corrected series of *depths* has not yet been furnished for either series, the depths are for the present omitted in both tables. The least depth marked upon any specimen was 85 fathoms for No. 4, and the greatest was 2070 fathoms for No. 12.

In stating the results obtained from the specimens, they will be referred to by the numbers as above given. Numbers 1 to 4 inclusive are composed of fine siliceous sands, the grains of which are mostly of small size with sharp angles. The organic contents are not abundant; of the calcareous Polythalamia there is scarcely a trace, but some of the siliceous Diatomaceæ may be found in the light parts which may be rinsed from the sand. Among the Diatoms numerous fragments and some perfect discs of Coscinodisci* are the most abundant. Some species of the genus Chætoceros† were also seen, which are believed to be of northern origin. No. 5 is a coarse gravel, composed of common and jaspery quartz, with some feldspar, &c. It is much the coarsest of all the specimens examined.‡

Some of the quartz grains are rounded by attrition, while a large portion are quite sharp and unabraded. Among the organic contents a very few Polythalamia were noticed with some Diatomaceæ and sponge spicules.

No. 6 is a fine calcareous mud which effervesces briskly with acids, and yields by this treatment a large residue of siliceous sand with some Diatoms and Spongiolites. This specimen is interesting as indicating the commencement of that great calcareous deposit extending nearly across the Atlantic, which will be referred to in subsequent paragraphs.

Nos. 7 to 21 inclusive are fine calcareous muds which effervesce briskly with acids, and abound in the calcareous Polythalamia and particularly in species of Globigerina. They also contain numerous and very interesting species of the siliceous Polycistins, Diatoms, and Spongiolites. The mineral residue from acids is usually quite small in relative amount, and consists of minute sharp-angled grains among which quartz predominates.

Nos. 8 to 21 inclusive contain, in addition to what is above mentioned, what appear to be well characterized *volcanic ashes*, in the shape of minute fragments of pumice and obsidian, crystals of various minerals single and in groups, with vitreous products penetrated with crystals. These substances generally form but a small portion of the residue left by the acids, and may be more readily detected when this residue is in water than when mounted in balsam. They are particularly recognizable in No. 14.§

* Many fragments and some very fine and perfect specimens of *Coscinodiscus oculus iridis*, Ehr., *C. borealis*, B., and *C. crassus*, B., were found in these specimens.

† Among these were *Chætoceros boreale*, B., and *C. furcillatum*, B. The latter occurs also in the Sea of Kamtschatka. See this Journal, vol. 22, pl. 1, fig. 4.

‡ The rinsings from the coarse gravel of No. 5 gave a few Polythalamia, and some Diatoms.

§ They are scarcely less so in No. 15 to 18. In the specimens No. 8 and No. 21 the volcanic products were found, but only in small proportion and after careful search.

No. 22 is a fine calcareous mud with some Globigerinæ. It is chiefly noticeable as leaving with acids a considerable amount of fine quartz sand mingled with microscopic globules of *iron pyrites*. It yielded no recognizable volcanic products and very few siliceous organisms.

Nos. 23 and 24 are similar in character to No. 22 but they yielded no globules of iron pyrites.

Some general remarks on the results of the examination of the specimens above referred to will now be given.

1st. The employment of acid enables me to correct an erroneous statement which I made sometime since concerning the deep soundings of the Atlantic. Having at that time only a small portion of the soundings, and being unwilling to destroy a morsel of matters so precious, I did not apply acids, and hence overlooked the portion of mineral matter which though often very small is *invariably present.*

2nd. The mineral matter in these soundings generally shows no signs of abrasion, the sharpest edges and angles of even the softest minerals being retained. The minute size of the particles and their sharp angular state appears to show that they have been quietly deposited from gentle currents and not subsequently disturbed. Even the coarsest and most abraded materials may have been deposited from icebergs.

3rd. The gradual increase of calcareous matter as the Gulf Stream is approached, and the presence of calcareous organisms from its western margin almost completely across the Atlantic is in accordance with observations previously made on the Coast Survey soundings of the Gulf Stream obtained farther south, which show that calcareous marls, rich in Polythalamia, Polycistins, Diatoms, and Spongiolites, form the bed of the Gulf Stream throughout its whole course as far as yet examined, and also occur in vast extent in the Gulf of Mexico.

4th. These marls contain a great number of undescribed organisms, both siliceous and calcareous. Many species which occur as far south as Florida and the Gulf of Mexico are found in the northern soundings above described, while some very remarkable species found in the northern soundings have not been detected at the southern localities, and vice versa. The description of the new species is in preparation for speedy publication.

5th. Only a few imperfect casts of Polythalamia and no well characterized green-sand casts have been detected in these northern soundings, while their presence is rather the rule than the exception with regard to the southern soundings above referred to.

6th. The occurrence of what appear to be volcanic products in the bed of the ocean for a distance of about twenty-two degrees of longitude, or about a thousand miles, is an extraordinary fact and one which deserves careful scrutiny. That any

one familiar with the microscopic appearance of volcanic ashes, &c., would pronounce these matters of volcanic origin I have no doubt. As, however, the ingenious suggestion was made to me that these igneous products might be derived from the fires of the ocean steamers, along or near whose pathway these soundings were made, it was important that these furnace products should also be studied. This I was enabled to do by the kindness of Geo. Manning, Esq., who procured for me from the steamers themselves, specimens of such matters as are thrown overboard from the ash pits of the steamers Asia and Baltic.

Careful examination of these specimens showed that they contained a group of products which could not possibly be confounded with the supposed volcanic matters. In fact there was no relation between the two classes of bodies except that both were evidently the results of intense heat upon different mineral matters. Among the furnace products of the steamer Baltic were numerous single and aggregated glass spheres of minute or even microscopic size, which if they should ever be found in ocean soundings would be very puzzling without this clue to their origin.*

7th. The question of the original source of the volcanic products is one of great interest. How far these plutonic tallies may have traveled and in what directions, whether from the Azores, the Mediterranean, or Iceland, involves a study of currents and an examination of soundings which are yet to be made.

The specimens of the second series were as follows:

No.	Latitude.	Longitude.	No.	Latitude.	Longitude.
1.	49° 12′ North.	49° 42′ West.	5.	49° 49′ North.	45° 54′ West.
2.	49 36 "	49 05 "	6.	49 50 "	44 43 "
3.	49 40 "	48 29 "	7.	51 43 "	13 44 "
4.	49 49 "	46 43 "			

* Since the above was written I have received through the kindness of Lieut. Maury a very extensive series of soundings made in the North Pacific, Sea of Ochotsk, &c., by Lieut. Rodgers, of U. S. Navy. I have had as yet no opportunity of studying these specimens, but my attention was attracted to one of them from its striking resemblance to soundings made in the Gulf Stream off Key Biscayne, Florida, by the U. S. Coast Survey. It was in fact a true Globigerina marl, largely composed of Polythalamia, but yielding also, like the Florida specimens, fragments and perfect specimens of Hyalea and other Pteropods. It also agreed with the Florida specimens in containing well characterized green-sand casts of Polythalamia. It differed however from the Florida specimens in containing very few siliceous Diatoms or Polycistins, forms which are remarkably abundant in the Gulf Stream and Gulf of Mexico.

This specimen presented another remarkable character, which I detected even with a common pocket lens. It contains a very large proportion of volcanic products, not better characterized than in the Atlantic specimens, but vastly more abundant, and of larger size. The perfect correspondence of these products to those in the Atlantic is additional evidence of the volcanic origin of the latter. On referring to the map for the position of this remarkable specimen, its latitude 30° 35′ north, longitude 130° 40′ east, placed it in the very place where a resemblance to the Gulf Stream of the Atlantic was to be expected, viz., in the "Japanese Gulf Stream." As for the volcanic products there are but too many active sources for such materials along the line of this Asiatic current.

They will be referred to by the numbers given in the above table.

Nos. 1 to 6 are calcareous muds, containing much mineral matter, and only a small portion of Polythalamia. The siliceous organisms are also comparatively few consisting of some large Coscinodisci, a very few Polycistinæ, and some Spongiolites. No volcanic products were detected.

No. 7 is also a fine calcareous mud showing to the naked eye but few Polythalamia, but rather rich in microscopic organisms, consisting of minute Polythalamia, with Polycistins, Diatoms, and Spongiolites. No volcanic products were detected.

Hoping that the above will answer the purpose of a general report upon the microscopic character of these soundings, I reserve for a subsequent publication the details of the zoological results afforded by these highly interesting series of soundings.

ART. XVI.—*Coal Fields of the East Indian Archipelago.**

Labuan, Bruni and Sarawak.—Little more than ten years ago, the only known coal-bed in the Indian Archipelago was that of Pulo Chermin, at the entrance of the Borneo River. Subsequent researches, however, shew that the mineral is scattered pretty plentifully over the area included in the great bank of soundings which extends to the southeast, from the Malayan and Indo-Chinese Peninsulas to the Bonirati Group, south of Celebes. But in countries where manufacturing industry has made little progress, coal is only required in large quantities for the use of steam vessels, and the beds become valuable or otherwise in proportion to the facilities offered for supplying depots. As freight forms the most important item in the cost, those coal fields which happen to be in the immediate route of steamers, and admit of their receiving it direct from the pit's mouth, are necessarily the most important, and it was for this reason that we gave precedence in our series to that of Mew Bay in the Strait of Sunda.

Of the coal fields of the northwest coast of Borneo, those of Labuan and Bruni, where the seams are of a thickness calculated to astonish the home miners, are capable of supplying steam lines in the neighboring seas for many years to come, and, although Labuan lies out of the direct track between Singapore and Hongkong, it is more than probable that when the increase of competition causes the new lines between India and China to be less profitable than at present, it will be found necessary, for the sake of economy, that the steamers should call at Labuan, either going or returning, for a supply of coal to last the entire round. Nor will much time be lost by so doing, as smoother water is ex-

* Cited from the Singapore Free Press, for March 6, 13, and April 3.

perienced during both monsoons on the coast of Borneo than on the other side of the China Sea, a point of importance to auxiliary screw steamers when making the passage against the monsoon. But the spirited proprietors of the Labuan mines do not seem disposed to await the course of events, and the steam-collier they have sent out to run from Labuan to this port and Hongkong, (a vessel of 1,000 tons burthen and peculiarly adapted for the service,) is likely soon to settle the question as to whether the produce of the mines of Borneo can compete with British coal at the Eastern depots. Sail-vessels are not well adapted for service as colliers in these seas, where the periodical winds blow for six months together in opposite directions, except when it happens that the mines and market are so situated with regard to each other that the passage can be made both ways with a fair wind, as is the case with Sourabaya and the coal fields of South Borneo.

The last overland mail brought intelligence that a company had been organized for working a coal field in Sir James Brooke's territory at Sarawak. Very little seems to be known about it except by the parties interested, but there can be little doubt of its becoming a valuable acquisition to steamers frequenting this settlement, as the distance across is rather under 500 miles. The Sarawak mine, however, from its inland situation, will not be so well adapted as a coaling station for steamers as that of Labuan, which lies on the shore of a navigable strait, so that passing vessels can load their coal from the pit's mouth without diverging from their course.

Banjar-Massin and Koti.—The island of Borneo appears to be one great coal field, for every large river intersects a coal-bed, and it seems only necessary to seek and mineral is found. Thus every settlement, indeed every spot frequented by Europeans, has its mines more or less convenient. Labuan, Bruni, Bintulu, and Sarawak, on the north coast, the banks of the Kapuas on the west coast, Banjar-Massin and the banks of the Great Dyak River on the south coast, and Pulo Laut, Pagattan and Koti on the east coast, each has its coal-field, although those only which we notice are worked at present for other than local purposes. The mines of Banjar-Massin, which lie about 70 miles above the town, on the banks of the Batu-Api River, are the most important of those at present worked within the Dutch-Indian territories, not on account of the superiority of the coal-measures, for the main seam is only 9 feet through, but owing to the favorable position of Banjar-Massin for communication with Sourabaya, the chief naval arsenal of the Dutch in these seas, and where the consumption of coals is probably greater than in any port of India excepting Calcutta. In addition to the supplies required for war-steamers, and for the boats employed in keeping up the

communication with Celebes and the Moluccas, steam engines are pretty constantly employed in pumping out the dry-dock and in working the machinery of the great steam factory, where the engines of government, and of the sugar *fabriques* in the eastern part of Java are made and repaired. The Banjar-Massin coal is well adapted for steam purposes, as it burns freely and does not cake or "clinker," but for the same reason it is not so well adapted for the forge as English or Australian Newcastle coal. The cost of the mineral, delivered at the depot in Banjar-Massin is 2 guilders (3s 4d) per ton, and the freight across to Sourabaya varies from 5 to 8 guilders more. It is usually exported in large blocks of an oblong form, the small coal being either thrown aside or kept for home use. Large prahus and square-rigged vessels belonging to Arab and native traders of Sourabaya and Grisse are chiefly employed in the transport, and as they would otherwise have to lie idle during several months of the year, the freight is sometimes very low. During the southeast monsoon, the voyage across, both ways, rarely lasts more than two or three days.

The mines of Koti lie on the banks of the river of that name, about eighty miles from the mouth. They are worked by Mr. King, an English trader who has resided there for some years past, but the demand is not very great, owing to their inconvenient position with regard to a market. The coal is of the same highly bituminous character with that of Labuan and Banjar-Massin. Whenever steam comes to be generally employed in these seas for the transport of merchandize, the Koti mines will be found useful in supplying coal depots in the Strait of Macassar. The distance across to Paré-Paré on the opposite coast of Celebes is about 100 miles.

Seams of coal have been found at Reteh and Palembang, on the east coast of Sumatra; near Macassar, on the island of Celebes; at Bawean, an island in the Java Sea; and at Bachian, in the Moluccas; but those we have already enumerated are the only beds that admit of being worked with convenience and profit. It will be found on examination that all these are included within the submerged plateau which extends from the south-eastern part of Asia nearly two-thirds of the distance across to the nearest point of the continent of Australia, and further examination will show that they occur only on those parts of the plateau which have been subjected to violent upheaval since the formation of the sedimentary rocks, a process which has tilted and broken through the strata, exposing sections to the view of any traveller who may be passing over the country. It is thus that every known coal field in this part of the world has been discovered, and we believe that in every instance the discoverers have been the natives of the country, to whom, indeed, the exist-

ence of some of the most important beds seems to have been known through many generations. Now there is no peculiarity in the geological structure of the regions where coal is known to exist, which renders them more favorably constituted for the formation of the mineral than other parts of the plateau, say the island of Singapore itself; indeed there is not only a possibility but a reasonable probability that it exists under our very feet. Certainly nature has not been so considerate as to display her workings to the public gaze, as is the case in the regions bounding us on either side; but does not science furnish us with the means of ascertaining the character of the earth's crust to any required depth, with small expense and labor, by means of boring? No doubt, were the result successful, an outcry would be raised against the government authorities for having heretofore neglected so simple and inexpensive a means of ascertaining the *internal* resources of the island, so that no movement can reasonably be expected in that quarter; but the authorities of the Steam Navigation Company would be fully justified in devoting a small portion of their immense revenue to carrying out a series of experiments, which, if successful, would be the means of curtailing their expenditure to the extent of some tens of thousands per annum. Probably no more favorable spot could be found for commencing operations than the immediate neighborhood of their depot at New Harbor, where the surface indications, shale and sandstone, are such as are always associated with the coal beds, although their presence does not imply the actual existence of the more valuable mineral. That such measures may be carried out even by private enterprise, will be seen by an extract we append, which gives the result of a similar experiment at Ipswich, a small but rising town of the Moreton Bay district of New South Wales, by two gentlemen, who, we are informed, follow the occupation of millers and storekeepers. The Moreton Bay district was not occupied until some years after this settlement had been formed, and the town of Ipswich is scarcely ten years of age. This successful experiment nearly doubled the value of the town allotments in the course of a few hours after the result became known:

"We have great pleasure in calling attention to the recent discovery of a valuable seam of coal on the property of Messrs. Walter Gray and Co., situated on the north bank of the Bremer, about one mile from the town. This desirable work was commenced some months ago, and notwithstanding great difficulties supervened, such as boring through masses of hard rock, those difficulties have been surmounted, and the discovery of a seam of coal nine feet in thickness has rewarded the exertions of the enterprising proprietors. The shaft was sunk to the depth of 100 feet before the miners came to the coal, and from the nature

of the superincumbent strata it is expected that the mine can be worked both with profit to the owners and security to the people employed. A sample of the coal has been forwarded to town, and has been submitted to the inspection of competent judges, who have pronounced it to be quite equal, if not superior, in quality to any hitherto discovered. It appears to be that description which is known as *caking* coal, and we understand it is very pure, and leaves after combustion a very small percentage of ash. The sample before us seems to be highly bituminous, and well adapted for the purpose of producing steam which sets machinery in motion.—*North Australian.*"

Since writing the above, while looking through the 1st volume of the *Journal of the Indian Archipelago* for information respecting the coal deposits of Kedah and Ligor, we came upon a paragragh (p. 165) to the effect that a mass of anthracite was discovered near the base of Pearl's Hill in 1846, when the excavations were being made for the foundation of Tock Sing's Hospital. It is singular that so certain an indication of the existence of coal in our immediate vicinity was not followed up, as a gallery driven horizontally from the base of the hill would soon have brought its contents to light. Certainly the value of anthracite as fuel was not so well known as at the present time, although then, as now, it was used by steamers in preference to bituminous coal throughout the United States; nor was the consumption of fuel by steamers frequenting this port equal to a twentieth of the present amount. The time has now arrived, however, when any delay in prosecuting an inquiry of so much promise would impair the enterprising character of the inhabitants of this settlement.

ART. XVII.—*Observations on the Zodiacal Light;* by Rev. GEORGE JONES, A.M., Chaplain United States Navy.*

To appreciate the vast amount of labor bestowed by the Rev. Mr. Jones on his zodiacal light researches, the volume whose title is given below should be carefully examined. It consists almost wholly of celestial maps with the position of the light noted down, as ascertained at each of his observations, the maps being the actual records as they were made by him at sea, accompanied by the notes or remarks that were written down at the same

* Observations on the Zodiacal Light from April 2. 1853 to April 22, 1855, made chiefly on board the United States Steam Frigate, Mississippi, during her late cruise in Eastern Seas, and her voyage homeward, with conclusions from the data thus obtained, by Rev. George Jones, A.M., Chaplain U. S. Navy:—being Volume III of the United States Japan Expedition. Washington, 1856.

time. There are 350 of these maps. The author has been scrupulously exact in giving his original records without any modification from views subsequently arrived at. The first 40 pages are devoted to historical and theoretical considerations, and include a brief explanation of the theory which he has been led to adopt.

There are points in the researches upon which more light is required; and Mr. Jones, aware of the doubts with which some of his observations may be received, and desirous also to give greater completeness to a subject that has occupied so much of his time, has now gone to the high plateau of Quito to continue his investigations. He has announced his safe arrival there, but has not yet sent forward any farther results.

The statements in the work most likely to be questioned are, the division of the light into a brighter centre and more diffuse borders by a boundary which is definable; the existence of a moon zodiacal, and the occasional waving character of the light. After citing from his account of his observations and certain general conclusions, we give his explanations of the theory which he favors, the existence of a nebulous ring around the earth. The objections brought forward by him to the prevalent view of a nebulous body around the sun, are here omitted. The subject is submitted to our readers without discussion.—Eds.

* * * * * * *

My first observations were of a very desultory kind. I contented myself with making records of having seen the Light, and with giving its boundaries, by written descriptions, in a general way. But the necessity of *precision* soon showed itself; and, as I went on, of yet still greater precision; and I then constructed a star-chart from an excellent little globe. By laying folds of paper below this, and sticking pins through the stars, I multiplied the charts, till, after nearly a year's work in this manner, I was able to have the chart cut in wood at Canton, and thus I found myself well prepared for work. My custom was, at evening, to watch for the earliest appearance of the Zodiacal Light; and, as soon as I could get reliable boundaries, to notice their course among the stars, and draw these boundary-lines on the chart, with such annotations as the case might require; then, again, after the interval of half an hour or an hour, to go out once more, and as the boundaries would be changed in that time, to take the new ones in a similar way; and so proceed till the light could be no longer seen: and thus also, in a reverse order, in the morning. And after having once fairly commenced—say about the first of March, 1853—I never failed for one evening or morning, (Sundays always excepted,) till our reaching home on the 22d April, 1855, to see, and, with one exception, to make record of the Zodiacal Light, when the moon and clouds did not

interfere to prevent. In the case of that one exception, I saw the light; but being shut up among the houses in Canton, I could not get reliable boundaries.

The development of facts in the Zodiacal Light came upon me gradually, and, before they had disclosed themselves, much valuable time in the high southern latitudes, at the early part of our cruise, was lost; on our return, however, we went still further to the south, and I was able to make amends in some measure for this loss.

There is no mention made in any books on the Zodiacal Light, of any differences in the light itself;* but I very soon began to notice that there was a Stronger Light at the central part, or along the axis; while, beyond this, on either side, and also above, a dimmer kind of light extended itself, as if the matter giving us this light was more condensed at its central parts, and was thinned out beyond. I have called these the *Stronger* and the *Diffuse* Light, and have marked the boundaries of the former on my chart by full lines, while the bounds of the Diffuse are designated by lines of dashes, each having the hours of the observation affixed to it. Sometimes, beyond the Diffuse Light, there was also what seemed to be, not a positive light, but rather as if the sky were slightly paled (if the reader will allow the word); so slightly, that I could not trust my own sight respecting it, till I had called in repeatedly the aid of other persons. I consider it only as the more diffuse matter greatly attenuated at its outer edge, which, by the sinking of the ecliptic towards the horizon, was now brought so as to make its reflection visible to us. In the case just referred to, it presently changed into the Diffuse Light itself. The Stronger Light is evidently the one of which Cassini has given the boundaries in his written accounts.

It is not to be supposed by the reader that any of these kinds of light was bounded by sharp lines easily detected in the sky. On the contrary, the stronger passed by degrees into the diffuse, and the latter also gradually faded away. Yet there was, in the former case, a line of greater suddenness of transition, which, when my eye had got accustomed to observations, I was generally able to make out without much difficulty; and this is the line or the boundary which is given in my charts. The outer boundary of the Diffuse Light was also tolerably well marked. That I was not fanciful in this, is shown by the frequency with which other persons on board, both officers and seamen, when requested to do so by me, and without any leading questions, drew boundary-

* Unless, as seems probable, the following extract from Mairan's *Traité Physique et Historique de l'Aurore Boreale*, refers to such a difference: "J'ai encore observé plusieurs fois, qu'après que la Lumière Zodiacale avait cessé de paraitre le soir sous sa forme de lance ou de fuseau, toute la partie du couchant démeurait plus éclairée que la reste du ciel, sur 30 ou 40 dégrès d'amplitude." P. 36.

lines which corresponded exactly with those which I had just drawn, mentally, myself. Sometimes they differed from me; but still the promptness with which they designated such boundaries is proof that the transitions were perceptible to the eye. Generally, much careful looking took place, and perhaps repeated attempts, before I ventured to draw my lines. Often I was in doubt after all possible pains-taking, and the doubts are noted down. As a general fact, late in the evening the Stronger Light would melt away gradually, or rather would seem to be merged in the Diffuse Light, which alone would be left, the latter at first with a degree of brightness greater than it lately possessed; and then the diffuse would pass away, in the increasing night. In the morning the reverse was the case. It should be here observed, also, that this gradation in the strength of the Zodiacal Light was not only lateral from the centre outward, but also from the horizon upward to the terminating point. But the transition, in this latter case, was by insensible degrees, except in the cases of a more intense light near the horizon; even the Stronger Light, towards its apex, was so dimmed as to be distinguished with great difficulty, and often I could make it out only by following up the boundary-lines from the lower portion.

I remember very well my feelings of surprise and wonder when the *lateral* changes in the Zodiacal Light, as the night advanced, for the first time forced themselves on my attention. Those changes, as may be seen from my charts, are of constant occurrence; yet I do not find them noticed in any writings on this Light, except an allusion by Cassini in one of his observations, in which, however, he tells us that, both then and afterwards, he could come to no certain conclusions as to their existence.*

These changes running all through the observations, will be found to be of great consequence when we come to draw conclusions from our data. They are greatest and most striking when the ecliptic has declined considerably towards the horizon; and there is great uniformity in them, but they are not without contradictions among themselves; but these incongruities are rare, and are probably owing to extraneous causes.† I would not

* "Je doutai si elle n'avait pas un peu de mouvement particulier vers le septentrion; car les deux plux luisantes d'Aries qu'elle frisait au commencement par son côte septentrional, furent ensuite comprises dans cette clarté; ce qui a été depuis confirmé par les observations des jours suivans. Mais je ne fus pas en être entièrement assuré ni alors, ni après plusiers jours, parceque l'extremité de cette clarté était de tous côtes trop douteuse, s'affaiblissant peu-à-peu; de sorte qu'il était extrêmément difficile de la déterminer précisement."—*Mémoires de l'Academie Royale des Sciences, tom. viii.*

† Cassini remarks on the character of the Zodiacal Light as follows: "Il ne faut néanmoins prétendre réduire les apparances de cette lumière à un régle aussi exacte que l'anneau de Saturne, parcequ'il s'en faut beaucoup qu'elle soit si bien terminée et qu'elle ait autant de consistence; étant assez évident, par les differences accident-

advise any one to draw conclusions from *exceptions*, in a matter where mistakes can be so easily made by the observer, but only from the general facts of this book; I have put down all, exceptions and incongruities as well as others, not feeling authorized to omit any portion; for who can say, in a new science, that what seem to be exceptions are not a part of the general rule.

Among the most important of these observations are those when the Zodiacal Light was seen near and at midnight, simultaneously on both the western and eastern horizons—a circumstance never observed before.* I had not expected it, and the manner in which it came upon me is recorded, with the care, also, to have other eyes than my own brought to bear on the subject, and also my carefulness in watching the western and eastern skies through all the changes of the light, from early in the evening till dawn. It is probable that this appearance can never be seen except when the ecliptic at midnight is at right angles, or nearly so, to the spectator's horizon; which can only be the case where his latitude is equal to the sun's declination, but on the opposite side of the equator. I saw this again in the following year; and in both instances the ecliptic was not only vertical, or nearly so, at midnight, but bore east and west from me; but the latter circumstance, I presume, had nothing to do with the results. I have been puzzled to know by what kind of lines to designate the boundaries of this midnight light; for it was very dim, quite as much so as the Diffuse Light; yet when I came to bound it by lines of dashes, I found they produced confusion when the Diffuse Light itself was marked down; so I gave it a line of alternate dashes and dots, and thus it is designated in the charts.

Sometime early in 1854, I saw in a newspaper a brief notice of the pulsations in the Zodiacal Light seen at the Kew Observatory; but as the newspaper did not state where they were observed, or the authority, and as I had now been observing for a year without having noticed anything of the kind, I set it down as an ocular deception, and the thing passed entirely from my mind. But in March of this year, I was surprised, one evening, at seeing the Zodiacal Light fade sensibly away, dimmed to almost nothing, and then gradually brighten again. This was repeated several times; but the effect, after all, was to leave me only in amazement and doubt. Subsequent nights, however, gave abundant exhibitions of this kind, of which, with the times and changes, I have made ample records with the particularity

ales qu'elle fait paraître d'un jour à l'autre, qu'elle reçoit des variations réelles, outre celles qui viennent des causes externes, comme des diverses dégres de la clarté de l'air et du concours de la lumierè des astres, et méme de la disposition des yeux de l'observateur."—*Mémoires de l'Academie Royale, tom. viii, pp.* 163. 164.

* Unless, indeed, we class this with what a German writer calls the *gegenschein*.

that the case required. It was a great satisfaction, after my return home, to find that Baron Humboldt had observed the same thing while in southern latitudes, though he thought it more probable that it was owing to "processes of condensation going on in the uppermost strata of air, by means of which the transparency, or rather the reflection of light, may be modified in some peculiar and unknown manner." My records, however, will show that there is a regularity of appearance at the closing off of these pulsations, which proves that they do not belong to so uncertain a cause as atmospheric changes, but to the nebulous substance itself. They seem to intimate a great internal commotion in the nebulous matter, for they were too rapid to be occasioned by irregularities in its exterior surface.

I noticed them again the following year, but must refer the reader to my records and charts. The changes were a swelling out, laterally and upwards, of the Zodiacal Light, with an increase of brightness in the light itself; then, in a few minutes, a shrinking back of the boundaries, and a dimming of the light; the latter to such a degree as to appear, at times, as if it was quite dying away; and so back and forth for about three-quarters of an hour; and then a change still higher upwards, to more permanent bounds.

A reference to the charts will show zigzag lines in some of them down near the horizon. These are the boundaries of a very effulgent light which appeared at the times specified, and within these bounds. It has no other distinction than its greater brightness, and the cause of it I cannot surmise. Cassini appears to have noticed the same thing as will be seen by reference to his annotations.

I now, however, come to what may perhaps be the most important of all these observations; but a part in which my observations are meagre, compared with the rest. I had, at an early period, queried whether the moon might not give a Zodiacal Light, and had given attention to the subject; but, probably, had looked too high up in the sky, and, at all events, had failed to see anything of the kind. But, one evening, when I was finishing some boundaries from the western sky, the quartermaster on duty said to me: "The moon is going to rise;" and, on crossing the deck, I was struck at once with the resemblance between the light then showing itself in the eastern sky and the morning Zodiacal Light, in every thing except its elevation. In breadth, in the peculiar boundaries laterally of the Zodiacal Light, and in coloring, it was all the same; and, in its subsequent rapid changes, it still kept strictly within the Zodiacal Light bounds. The following night I was prepared to make records; and I never failed afterwards to watch for recurrences of such light. But they did not often present themselves; for

the ecliptic should be at a high angle, otherwise the light is apt to be so scattered along the horizon as to be unsatisfactory. It also happened, that we almost always had cloudy weather when such observations are most desirable—namely, at the full of the moon. * * * *

On two occasions, March 6th, and December 25th, 1854, I had also an undoubted *joint sun and moon Zodiacal Light.* That is, when the moon was about its first quartering,* and, at the time of the observations, about 63° above the western horizon, a bright streak appeared in the western sky, along the ecliptic; the joint light from the sun and moon, reflected from the nebulous matter, being apparently sufficient to overcome the bright moonlight in our atmosphere, and thus to make itself manifest. On both occasions I brought other persons to look (in the latter case, the captain and several other officers), whom I got to draw boundaries which corresponded to my own view of the subject. The latter occasion was also the more striking, because the streak of light did not stretch up exactly *towards* but *to one side* of the moon, that satellite having then a southerly latitude of four and a half degrees.

The observations here given commence on the 2d day of April, 1853; for, although I had been a careful observer since December 22d of the previous year, I consider the interval as having been necessary in order to gain experience, and I have consequently rejected all up to the period mentioned. My first intention was to reject still more, and to commence this publication with June of that year; but the extraordinary interest of some of the observations in April, and the great care which I took in them to be precise as well as correct, have led me to insert them. The *unbroken* series commences at June 7, 1853. From that time, till our arrival in New York on 22d April, 1855, every observation is recorded; and, except on Sunday, I never once failed to have observations, if the moon or clouds did not prevent. * * * * * *

At this stage of our work, effected and proposed, it may, perhaps, seem to be premature to draw conclusions; but still there are certain things that seem to force themselves on the mind from the data here afforded; and, if the conclusions which I shall now proceed to draw are not decisive to the reader's mind, they can at least furnish subjects for discussion that may, in the end, bring us to the truth.

It seems to be quite conclusive, on an inspection of these charts, that *we never, at any one time, see the whole actual extent of the Zodiacal Light.* This subject can perhaps be elucidated by noticing a common event,—a cloud, silvered at one edge by the

* March 1854, first quarter at Greenwich, 6*d*. 7*h*.; December 1854, do. 26*d* 0*h*. 37*m*.

rays of the declining sun. The sun may be shining on the bordering, quite around that cloud; and, if so, it is sending off, from every portion of the border, an equally brilliant, silvery light. But our eye is in a position to catch this reflection from only one portion of it, and the rest is dull to our vision. If we could with great rapidity change our positions, other portions of the silvered edge would show themselves according to our changes of place. So, also, when a rainbow is presented to our eye: the myraids of drops of falling water in the whole rain-shower are sending off, from each drop, reflections of light in all directions, and the universal atmosphere about us is full of these brilliant, variously-colored rays; but only that portion which, to us, forms the rainbow-arch, can reach our eye, and all the rest is lost to our sight.

So it is also with the Zodiacal Light; and the proof that we never see the whole of its extent at once, is manifest in the following facts:

1. That when I was in a position *north* of the ecliptic, the main body of the Zodiacal Light was on the *northern* side of that line.

2. When I was *south* of the ecliptic, the main body of the Zodiacal Light was on its *southern* side.

3. When my position was *near* or *on* the ecliptic, this Light was equally divided by the ecliptic, or nearly so.

4. When, by the earth's rotation on its axis, I was, during the night, carried rapidly to or from the ecliptic, the change of the apex, and of the direction of the boundary-lines, was equally great, and corresponded to my change of place.

5. That, as the ecliptic changed its position as respects the horizon, the entire shape of the Zodiacal Light became changed, which would result from new portions of the nebulous matter coming into position for giving us visible reflection; while portions lately visible, were no longer giving us such a reflection.

*A plane passing through the centre of the Zodiacal Light, as it shows itself through the varying latitudes of these observations, would correspond pretty nearly with the ecliptic;** but how near the two planes approach to a coincidence, it seems to be yet impossible to say. Through all of April, 1853, and December, 1854, there appear to be proofs of an evident crossing of the two planes. Through July of 1854, the apices, in the evening, were decidedly on the northern side of the ecliptic, though my latitude was only about 25° N; while, in September of the same year, though my latitude was nearly as before, the apices were on the southern side of the ecliptic, as shown by my morning observations; the

* Which is the reason why I have chosen the ecliptic for the central line of my charts; and why I refer so often to the position of the spectator as regards the *ecliptic*.

mornings then being very favorable for correct observation, on account of the high angle of the ecliptic with the horizon. Again, in April, 1855, the apices and greatest body of the light, were north of the ecliptic, even at times when I was, myself, to the southward of that line; as was the case in the first hours of the evening observations, up to the 13th of that month. The following general view rather shows us that there is something on this subject which may yet be learned, than that we have now the materials for anything definite and certain on the subject.

1853. April.—The planes of ecliptic and Zodiacal Light cross each other.

July.—By evening observations, the apex of Zodiacal Light appears to be north of the ecliptic. Morning observations are not satisfactory, either way.

1854. March 27 to April 18, strong proofs of crossing of the planes, by both morning and evening observations.

July.—Apex decidedly to the northward, by both evening and morning observations.

September.—Apices on the south, by morning observations, during this month.

December.—Apex decidedly to the northward, through all this month.

1855. January.—Apex as decidedly to the south of the ecliptic, by both morning and evening observations.

March.—Apex south of the ecliptic, by evening observations; the morning observations place it on the ecliptic.

April.—Apex north. No signs of a crossing of planes.

* * * * * * *

[The discussion of theories here follows in the volume and after objections to others, he comes to the one adopted.]

The hypothesis of a nebulous ring, with the earth for its centre.—There are certain deductions which appeared to come up in the examination of the preceding theories, which I will now bring together, and exhibit in a united form. They are: 1. That the substance giving us the Zodiacal Light must be *equally near* to us in all its parts, inasmuch as the lateral changes of the light—*i. e.* the changes of boundaries—have a uniform character, and mostly a parallelism in their whole extent from apex to base; 2. That no part of this substance can be *very remote* from us, inasmuch, as the outlines of the light, were clearly and decidedly affected by my own position on our globe, and even by my change of position, in a single night; and 3. That the laws of reflected light require an arrangement, or a shape, of this nebulous matter, which will give us, at the base of the Zodiacal Light,

larger angles between the lines of the incident and reflected light, than at other portions, and also a regular decrease of such angles from the base to the apex of the light, as produced by such a shape. These three requirements appear to be fully met by an hypothesis, which, if the theories already examined are untenable, is now the only one remaining to us.

The hypothesis is that of *a ring around the earth.*

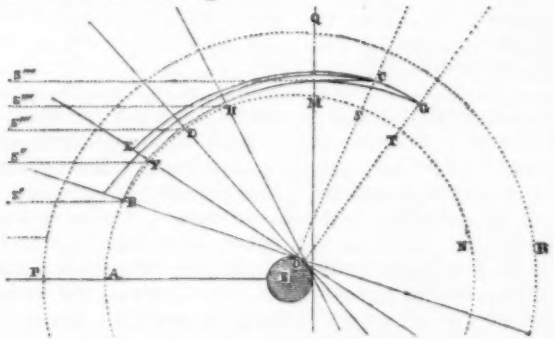
The thought is a somewhat startling one, yet startling only from its novelty; for it is entirely in accordance with what we know of one of our sister planets (Saturn), and also with the whole of Laplace's celebrated theory of the formation of globes.

That great writer, after stating his ideas of the central condensation from an immense body of nebulous, rotating matter, and thus of the formation of our sun, and of the rings about him, produced from the remainder of that nebulous matter, thus proceeds:

"If all the particles of a ring of vapors continued to condense without separating, they would at length constitute a solid or a liquid ring. But the regularity which this formation requires in all the parts of a ring, and in their cooling, ought to make this phenomenon very rare. Thus, the solar system presents but one example of it—that of the rings of Saturn. Almost always each ring of vapor ought to be broken into several masses, which, carried on with velocities differing little from each other, would continue to circulate at the same distance around the sun. These masses ought to take a spheroidal form, with a movement of rotation in the direction of the rotation, since the inferior molecules have a motion less than the superior ones; they have thus formed so many planets in a state of vapor. But, if one of them has been sufficiently powerful to unite, successively, by its attraction, all the others around its centre, the ring of vapor will have thus become transformed into only one spheroidal mass of vapors, circulating around the sun with a rotation in the same direction as its revolution. Now, if we follow the changes which further cooling ought to produce in the vapory planets, of whose formation we have just spoken, we shall see grow up in the centre of each of them, a nucleus, incessantly increasing by the condensation of the atmosphere which surrounds it. In this condition, the *planet* resembles perfectly the sun in the nebulous state, in which we have just been considering it; the cooling ought, then, to produce, at different limits of its atmosphere, phenomena similar to those we have described; namely, rings and satellites circulating around *its* centre, in the direction of its motion of rotation, and turning on their axes in the same direction."—*Systéme du Monde. Paris edition:* pp. 467–468.

This great theory of Laplace, called his nebular theory, appears to be looked upon by astronomers with wonder, almost

with awe, and as a thing which they may scarcely dare to touch. It is regarded with favor, yet there are few cosmologists who venture a decided opinion upon it; and, indeed, while there are few points from which it can be controverted, Laplace himself seems to have exhausted what can be said in its favor, in the few lines which he has given to it, in a manner far from positive, and in a retired corner of his book. If that theory be true, however, we have reason to think that no one of the planets may have absorbed in itself all the nebulous matter of the ring from which it was originally formed; and that, consequently, there may be, to each of them, a remainder substance, in the form of a ring, or rings, with the planet for its centre. In the case of Saturn, such rings are visible by the aid of our glasses. To Jupiter, such rings have given four satellites; for our own globe, one satellite has been produced. And we may well query, whether there may not be still a remainder of the nebulous matter left from the ring originally producing the earth; the nebulous substance of that ring not having been all exhausted in the formation of our earth and its moon, and showing itself in a ring such as we are now considering.



Between PQR and AMN the nebulous ring.—E, the Earth.—S′ B, S″ F, etc. direction of the Sun.—B, F, D, H, M, horizons; B, at 4ʰ 30′; F, at 3ʰ 30′; D, at 2ʰ 30′; H, at 1ʰ 30′; M, at midnight.—S, T, vertices; S, at 4ʰ 30′; T, at 3ʰ 30′.

But avoiding any consideration of these topics, as regards other planets, and confining ourselves simply to the facts of the Zodiacal Light, and of a ring central to the earth, to which they seem to lead us, we proceed to apply the results of Bouguer's experiments to this case.

In the annexed diagram, constructed according to this supposition,* the observation quoted in the former sections—that of

* The relative proportions of the earth and the ring, and also its distance, are, of course, not given in this diagram with any effort at certainty; the upward extent of the ring is probably far greater than can be here represented. The diagram, is, however, sufficiently correct for our present purposes of elucidation.

September 4th, 1853—is again taken as an example, and for the same reason; namely, that it is a simple one, and one also in which the spectator is near the plane of the ecliptic. The horizons, at $4^h\ 30^m$, $3^h\ 30^m$, $2^h\ 30^m$, $1^h\ 30^m$, and at midnight, are given, together with the lines of the spectator's vertices, as well as his positions, *o o*, &c., at $4^h\ 30^m$, and $3^h\ 30^m$, &c. A B F C are the boundaries of the Zodiacal Light at $4^h\ 30^m$, and E F G at $3^h\ 30^m$; the apices C and G are carried a little above the more condensed portion of the ring; but the reader is at liberty to suppose them to be at any other part, as he may think best. The direction of the sun is given; and S′, S″, S‴, S⁗, S⁗′, are supposed to be rays of light proceeding from that luminary.

In this diagram, the sun's rays being S′, S″, &c., B O, F O, &c., will be the reflected rays; and the several angles between these lines of incidence and reflection, together with the number of rays reflected to the eye, out of every 1,000 incident rays, according to Bouguer, are in the following table:

Angle.	Rays reflected from smooth water.	Rays reflected from plate-glass not quicksilvered.
S′, B O ..... 161°	343	422
S″, F O ..... 146°	184	270
S‴, D O ..... 131°	101	162
S⁗, H O ..... 116°	59	105
S⁗′, at midnight, 90°	18	25
S⁗′, C O ..... 67°	18	25

Still acknowledging that we know not what nebulous matter is, and therefore that we cannot, with certainty, argue about its properties of reflection; yet still claiming as a high probability, amounting almost to certainty, that the laws of reflection, applying to all other bodies, to solids, to vapors, to the molecules of our atmosphere, apply also to nebulous matter, we find in the above table a strong argument for such a ring around the earth. The figures, taking either of the two columns, for water or for glass, correspond in a very striking degree with the varying intensity of the Zodiacal Light, from the base upward, as we have it on any clear morning or evening when the ecliptic is at a high angle with the horizon, and when, consequently, the nebulous figure is not brought angularly to our eye. They also correspond to what is, indeed, almost synonymous with that which has just been stated—namely, to the fact, that at $4^h\ 30^m$, the Zodiacal Light at the horizon is far greater at its base than it is at $3^h\ 30^m$; at $3^h\ 30^m$, than it is at $2^h\ 30^m$, &c., back to midnight. Any person, who has ever looked attentively at this light, when making a high angle with his horizon, will see at once the coincidence between the proportions in the above figures, showing the number of reflected rays, and what has been always presented to his eye. If the reader will also carry these lines of incident and reflected light beyond the midnight horizon-line, to

any point there of the nebulous ring, he will see how we may easily get what is referred to in my charts under the German name of *gegenschein*—*i. e.* a dim light, seen, when the circumstances are favorable for it, in those portions of the sky opposed to the sun. This hypothesis shows also, very clearly, how I could have the Zodiacal Light above both horizons at the midnight hours, as I was often able to do, and it harmonizes fully with the strength of the light as then presented to the eye.

Indeed, while Bouguer's results are antagonistic to all the theories discussed in the previous sections, and seem to be utterly irreconcilable with them, they fully coincide with this, in every one of its aspects; and, so far as they can go, they satisfy the mind, in all the varying characters of the Zodiacal Light.

I said, so far as they can go; for there are points in this subject, such as the pulsations of light, and what in the annotations to these charts is called the "effulgent light," which belong to something in the nebulous matter which we have not yet fairly reached, and which must be left for explanation to yet further observations.

While there are some things still left unexplained, I have yet, not been able to see anything in this hypothesis antagonistic to the facts of the Zodiacal Light. On the contrary, almost all of them are explained by it; and they all, as far as I can perceive, fully harmonize with it, through the whole of the manifold changes which the light underwent, either from the changes of the ecliptic towards any fixed spot, or from my numerous and great changes of latitude during our cruise. In examining them in detail, we must remember the deduction just drawn, (see p. 167, last paragraph,) from the general mass of data—namely, that as the spectator's place is changed relatively to different portions of the nebulous ring, such portions change, for him, their reflected light; just as is done every day, to our eye, by clouds or other terrestrial objects. Remembering this, he will, I think, fully understand why, when I was on the northern side of the ecliptic—*i. e.* towards the northern edge of the ring—its reflection was chiefly on that side; why its southern portions gave me the chief reflection when I was towards its southern side; and so, why all the various aspects detailed in Nos. 1, 2, 3, 4, 5, were, at different hours or seasons, presented to my eye.

If it should be objected to my deductions from Bouguer's law of reflection, that the intensity of light, which his results would give this ring when brought between our eye and the sun, ought to make the ring a very striking object to us during a total eclipse of the sun; I reply, that the increased intensity of the Zodiacal Light, from the apex to base, is a *fact* independent of any theories; that, on any supposition of causes, it can scarcely be doubted that this reflection, so increasing from apex to

base at the horizon, goes on still increasing in force below the horizon, towards the direct line between our eye and the sun; and that, consequently, if the Zodiacal Light is not a striking object in a total eclipse, stretching off from each side of the sun, this fact is not more against the hypothesis of a ring around our earth, than against a ring around the sun or in any other place. As respects such eclipses, however, if the observer of them is in a high latitude, north or south, he will, except at only one portion of the year, have the ecliptic at a very low angle with his horizon (even, under the best circumstances, not at a high angle,) and therefore cannot expect to have a good exhibition of the Zodiacal Light at the time of eclipse. There was, however, an observation made in Peru, during a total eclipse, on the 30th of November, 1853, from which we might expect something of a more decisive character. The observer was Prof. Carlos Moesta, of the Observatory of Santiago, who at the suggestion of Lieutenant Gillis, U. S. N., was sent to Peru, by the government of Chili, for that purpose, and who afterwards made a highly interesting and valuable report to the Minister of Public Instruction, with a sketch of the heavens as they appeared at the time of the total obscuration of the sun. His place of observation was in lat. 14° 21′ 21″ S, and consequently he had the ecliptic at a high angle with his horizon: the sun at that time having a declination of 24° 42′ S,—*i. e.* 7° 21′ south of the observer. Every thing was favorable, as regards an observation for the Zodiacal Light, on that occasion; and we have, in his engraved plate, in addition to the corona usual in total eclipses, a long ray projecting from the sun S 70° E, and another, also a prominent and striking object, but not quite so long, stretching off N 80° W. He says: "Nearly all the northern part of the ring [corona] was uniform; the opposite side was evidently composed of numerous rays, which appeared to come from the ring, and all which had the same length, with the exception of two very large ones. Of these last, one was in an upward direction, and inclined about 20° S of E, and according to estimation, its upward extent is as large as a diameter of the moon; the other extended from the ring downward, not diametrically opposite to the former, but inclined about 10° N of W, and was a little shorter than the other. The appearance of these two rays was much like that of a comet, narrower at the end than near the nucleus, and clearly radiating in its structure; since it could be seen, perfectly well that these rays were not of a homogeneous light, but composed of a vast number of very small rays. Soon after the eclipse I made the annexed sketch, in which I have endeavored to represent this ring [corona] as nearly like the original as possible."

It should be added to this that Mr. Moesta's drawing was from a view through the telescope; I have, myself, always found the

naked eye better for viewing the Zodiacal Light than telescopes. Through our ship's glasses I was never able to see it all.

If we could have a Zodiacal Light of an undoubted character produced by the *full* moon, not only would the question before us be set at rest, but the ring would be shown to be within the orbit of the moon: and how near we came to a case of that kind on the evening of February 14,* 1854, the reader will decide for himself. There was no subject connected with these observations, in which I was so carefully watchful; but, in summer, the moon, when full, must rise long before the crepuscule ceases, and it is only in winter months that satisfactory observations of this nature can be made; and in the few instances of this kind which offered, clouds interfered to prevent them.

For myself, I have no doubt that what I saw, in all the cases given in these charts, was really *Zodiacal Light produced by the moon.* When the equator and ecliptic were furthest removed from each other, the light still kept closely with the ecliptic, and, therefore, could not have been atmospheric; and the boundaries, though only in one case having the altitude of the sun's Zodiacal Light, still, as far as they ascended, always resembled fully those produced by the sun.

From the deductions made, (see p. 167, last paragraph,) it is apparent that we cannot expect to get a parallax of this ring; and that we can hope for only approximations to its width. In the morning observations I appear to have got the full lateral extent northward of the Stronger Light, about 30°; and of the Diffuse Light 45°; but the evening observations of June, July, and August, 1853, differ somewhat from these. The inference from the whole of these data would seem to be about 60° for the full width of the Stronger, and 90° for that of the Diffuse Light.

I endeavored to have simultaneous observations made in Connecticut while I was in the extreme southern latitudes, but did not succeed.

This ring must, according to the laws of matter, rotate on its centre; and it seems to be full of commotions within itself. The existence of the pulsations, so often referred to in this book, seems scarcely to admit of a doubt, recorded as they have been by observers in such distant quarters of the globe. They were, as a general thing very obscurely marked; but at times they appeared to be so decided that I had no longer a doubt of their reality. They could scarcely be owing to irregularities on the surface; for the changes appear to have been too rapid and extensive for such a cause. But that is possible. The following, respecting the rings of Saturn, is from Laplace's *Mécanique Céleste*:

* The moon was full at Greenwich February 12. 14*h*. 56*m*.; allowing for the difference in longitude, the observation was 1*d*. 6*h*. 43*m*. after the full; the next evening's observation, with still more decided results, was 2*d*. 7*h*. 28*m*. after the full.

"Hence it follows that the separate rings which surround the body of Saturn, are irregular solids, of unequal width in the differents parts of their circumferences; so that their centres of gravity do not coincide with their centres of figure. These centres of gravity may be considered as so many satellites, which move about the centre of Saturn, at distances depending on the irregularities of the parts of each ring, and with velocities of rotation equal to those of their respective rings."—*Bowditch's Tr.*, Vol. V, p. 516.

If we allow an irregularity of width to the earth's ring, it may account for the changes in its intensity of light; the Zodiacal Light this spring (1856) having been considered as of much greater brightness than in previous years.

If this nebulous matter gives us its reflected light only from certain portions of it—*i. e.* only from portions in position for admitting such reflection to our eye, may not the light from the tails of comets* (query: portions of *very* elliptic rings, the plane of the rings then coinciding with our eye?) be given and withdrawn in the same manner; so that, instead of such appendages suddenly shot out, and as suddenly withdrawn or dissipated, and at times, contrary to all laws of dynamics, preceding the body from which it emanates, we have, more philosophically, a substance always permanent, but giving its light to our eye only in certain portions of its orbit?

ART. XVIII.—*On some Compounds of Ethylene;* by H. S. BUFF. [Communicated to this Journal by A. W. HOFFMAN, Ph.D.]†

AMONG the hydrocarbons which are capable of replacing hydrogen, the radicals of the general formula $C_nH_{(n+1)}$ *i. e.*, the homologues of ethyl, are best examined. There is another class of hydrocarbons which may be represented by the general formula $C_nH_{(n-1)}$. The only well known term of this series is the radical allyl C_6H_5 to which the attention of chemists has been especially called of late by the researches of Messrs. Hoffmann and Cahours on allylic alcohol. These researches have established the most perfect parallelism between the two classes of radicals and their derivatives. Both the radicals $C_nH_{(n+1)}$ and $C_nH_{(n-1)}$ are *monatomic*, *i. e.*, molecules capable of replacing

* "The tail of the great comet of 1680, immediately after its perihelion passage, was found by Newton to have been no less than 20,000,000 of leagues in length, and to have occupied only two days in its emission from the comet's body; a decisive proof, this, of its being darted forth by some active force, the origin of which, to judge from the diameter of the tail, must be sought in the sun itself."—*Sir J. Herschell's Outlines of Astronomy.*

† From the Proceedings of the Royal Society, received June 10, 1856. Read the 19th June, 1856.

one equivalent of hydrogen. These two classes stand in the closest relation to each other, and it is by no means improbable that one class may pass over into the other, for instance, that the radical propyl C_6H_7 or a propyl compound may be converted into allyl or an allyl compound.

There exists a third series of hydrocarbons, which, again both by composition and origin are closely allied to the former two. They are represented by the general formula CnHn and methylene C_2H_2, ethylene C_4H_4, and propylene C_6H_6 are well known terms belonging to this series. These hydrocarbons are also radicals, they differ however, in their nature essentially from those of the former groups, inasmuch as they are *biatomic* molecules, *i. e.*, molecules capable of replacing 2 equiv. of hydrogen.

There exist parallel with these three series of radicals which form alcohols, three other groups of radicals, which in *acids* play exactly the same part that in the *alcohols* is assigned to the hydrocarbons. These acid-forming radicals contain, in addition to carbon and hydrogen, oxygen or other elements belonging to the oxygen group. They are closely connected with the radicals of the alcohols and this close connection is particularly well established between the first series of *alcohol-forming* radicals and the corresponding series of *acid-forming* radicals.

Methyl, $C_2H_3 - 2H + 2O =$ Formyl, C_2HO_2
Ethyl, $C_4H_5 - 2H + 2O =$ Acetyl, $C_4H_3O_2$
Propyl, $C_6H_7 - 2H + 2O =$ Propionyl, $C_6H_5O_2$

Formic, acetic and propionic acids are formed by the imperfect oxydation of methyl-, ethyl- and propyl-alcohol; and we may consider them to be simple substitution products of these alcohols.

By means of the electric current we are able to produce ethyl, methyl and hydrogen from propionic, acetic and formic acid, and these acids we may reproduce again by the action of hydrate of potassa on the cyanogen compounds of hydrogen, methyl and ethyl.

Both series of radicals are chained together by these reactions, and we may view acetyl and propionyl as formyl, the hydrogen of which is replaced by methyl and ethyl.

Formyl, $= C_2(H)O_2$
Acetyl, $= C_2(C_2H_3)O_2$
Propionyl, $= C_2(C_4H_5)O_2$

There is no doubt that the same relation exists between the hydrocarbons of the other series of radicals and the radicals of the corresponding acids, between allyl C_6H_5 and the radical of acrylic acid, acryl $C_6H_3O_2$ and between methylene C_2H_2, ethylene C_4H_4, propylene, &c., and the radicals of the bibasic acids, which are homologues of succinic acid $C_8H_6O_8$.

The biatomic radicals are in general less studied than the monatomic radicals; still they occur in many compounds, and are met with in different departments of chemistry.

In addition to the terms already mentioned, we find them in the phenyl, benzyl, napthyl and other series.

In the hope of adding some facts to the history of the polyatomic radicals I have made some experiments with chlorid of ethylene $C_4H_4Cl_2$.

This compound, as well as bromid of ethylene, refused to act in many instances, in others it underwent the same change which is induced by the action on it of a solution of potassa in alcohol, splitting into the compound C_4H_3Cl and hydrochloric acid.

On boiling chlorid or bromid of ethylene with an alcoholic solution of sulphocyanid of potassium, a very definite reaction takes place. The change being completed, the alcohol is separated by distillation, and the residue treated with a small quantity of cold water in order to remove chlorid or bromid of potassium, which is produced and the excess of sulphocyanid of potassium. The more or less colored residue is then dissolved in boiling alcohol, and the solution, after digestion for some time with animal charcoal and a few drops of hydrochloric acid, filtered while hot. This solution deposits on cooling brilliant and large rhombic plates of a hard and brittle white substance.* The analysis of this substance leads to the formula

$$C_4H_4Cy_2S_4$$

and its formation may be represented by the equation

$$C_4H_4Cl_2 + 2K\,CyS_2 = 2K\,Cl + C_4H_4Cy_2S_4,$$

which in the conception of this view may be called *anylene-sulphurous* acid, the cyanogen is replaced by hydrogen, whilst the sulphur has been oxydized into the compound radical S_2O_6, which in sulphurous acid we assume united with hydrogen.

$$\left.\begin{matrix} H \\ H \end{matrix}\right\} O_2 \quad \text{Two molecules of water,} \quad \left.\begin{matrix} H \\ H \end{matrix}\right\} O_2 \qquad \left.\begin{matrix} H \\ K \\ K \\ H \end{matrix}\right\} S_2O_6 \quad \text{Two equivs. of bisulphite of potassium,} \quad \left.\begin{matrix} H \\ K \\ K \\ H \end{matrix}\right\} S_2O_6 \qquad \left.\begin{matrix} \text{Ethylene-} \\ \text{sulphurous} \\ \text{acid,} \end{matrix}\right\} \left.\begin{matrix} H \\ C_4H_4 \\ H \end{matrix}\right\} \left.\begin{matrix} S_2O_6 \\ S_2O_6 \end{matrix}\right.$$

Since we find that the hydrogen-molecules in polybasic acids are replacable by two or more molecules of different metals or radicals, witness tartrate of potassium and sodium, oxalovinate of potassium, the idea naturally suggests itself that the biatomic alcohol-forming radicals may be capable of uniting two molecules of different elements or compounds of the oxygen group. It is

* Whilst Mr. Buff was engaged in these researches, Mr. Tannenschein has communicated some experiments made in the same direction, which have likewise led to the discovery of this substance. Tannenschein's results, which are published in the Journ. für prac. Chem. June, 1855, came to our knowledge only after a summary of the results had been sent to the editor of the Ann. der Chem. und Pharm.—A. W. H.

probable, for instance, that the ethionic acid, discovered by Mr. Magnus, may be such a compound, namely, *ethylene-sulphuro-sulphurous acid.*

Disulphetholic acid $\left.\begin{matrix}H\\C_4H_4\\H\end{matrix}\right\}S_2O_6S_2O_6$ Ethionic acid $\left.\begin{matrix}H\\C_4H_4\\H\end{matrix}\right\}S_2O_6S_2O_8$

The following table contains some of the known ethylene and succinyl compounds compared with the corresponding derivatives of the ethyl and propionyl series.

Compounds of the Alcohol-forming Radicals.

Ethyl Series.		Ethylene Series.	
Ethyl,	$\left.\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right\}$	Ethylene,	C_4H_4
Chlorid of ethyl,	C_4H_5Cl	Chlorid of Ethylene,	$C_4H_4Cl_2$
Sulphid of Ethyl,	$\left.\begin{matrix}C_4H_5\\C_4H_5\end{matrix}\right\}S_2$	Sulphid of Ethylene,	$C_4H_4S_2$
Mercaptan,	$\left.\begin{matrix}C_4H_5\\H\end{matrix}\right\}S_2$	Sulphocyanid of Ethylene,	$\left.\begin{matrix}C_4\\C\ H_4\\Cy\end{matrix}\right\}\begin{matrix}S_2\\S_2\end{matrix}$
Sulphocyanid of Ethyl,	$\left.\begin{matrix}C_4H_5\\Cy\end{matrix}\right\}S_2$	Ethylene-mercaptan,	$\left.\begin{matrix}H\\C_4H_4\\H\end{matrix}\right\}\begin{matrix}S_2\\S_2\end{matrix}$
Bisulphid of Ethyl,	$C_4H_5S_2$	Bisulphid of Ethylene,	$C_4H_4S_4$
Ethylsulphurous acid,	$\left.\begin{matrix}C_4H_5\\H\end{matrix}\right\}S_2O_6$	Ethylene sulphurous acid,	$\left.\begin{matrix}H\\C_4H_4\\H\end{matrix}\right\}\begin{matrix}S_2O_6\\S_2O_6\end{matrix}$
		Ethylene sulphuro sulphurous acid,	$\left.\begin{matrix}H\\C_4H_4\\H\end{matrix}\right\}\begin{matrix}S_2O_6\\S_2O_8\end{matrix}$
Sulphovinic acid,	$\left.\begin{matrix}C_4H_5\\H\end{matrix}\right\}S_2O_8$		

Compounds of the Acid-forming Radicals.

Propionyl Series.		Succinyl Series.	
Chlorid of propionyl,	$C_2(C_4H_5)O_2Cl$	Chlorid of succinyl,	$C_4(C_4H_4)O_4Cl_2$
Propionic acid,	$\left.\begin{matrix}C_2(C_4H_5)O_2\\H\end{matrix}\right\}O_2$	Succinic acid,	$\left.\begin{matrix}H\\C_4(C_4H_4)O_4\\H\end{matrix}\right\}\begin{matrix}O_2\\O_2\end{matrix}$
Anhydrous propionic acid,	$\left.\begin{matrix}C_2(C_4H_5)O_2\\C_2(C_4H_5)O_2\end{matrix}\right\}O_2$	Anhydrous succinic acid,	$C_4(C_4H_4)O_4O_2$
Propionyl amid,	$N\left\{\begin{matrix}H\\H\\C_2(C_4H_5)O_2\end{matrix}\right.$	Succinamid,	$\left.\begin{matrix}N\\\\N\end{matrix}\right\}\begin{matrix}H\\H\\O_4(C_4H_4)O_4\\H\\H\end{matrix}$

ART. XIX.—*On the Rose-colored Mica of Goshen, Mass.*; by J. W. MALLET, Ph.D., Professor of Chem. in the Univ. of Alabama.

THE very beautiful mica which occurs in finely developed crystals of a delicate tint of rose-red at the above-named locality has been usually considered as Lepidolite, mainly on account of its color; but in Dana's Mineralogy* it is noticed as "of difficult fusibility and slight lithia reaction, and possibly not belonging to the species Lepidolite."

Wishing to determine the true mineralogical character of this substance I resolved to ascertain the nature and amount of its alkaline constituents, and accordingly reduced a pure specimen to powder, and decomposed it by fusion with carbonate of lime and a little chlorid of calcium. The earths and oxyds of heavy metals having been removed in the usual way, and ammoniacal salts expelled, the chlorids of the alkalies were treated with a mixture of ether and absolute alcohol, and chlorid of lithium having been extracted by this solvent, the chlorids of potassium and sodium were separated by chlorid of platinum.

The mica was found to yield:

Potash,	9·08 p. c.
Soda,	·99 "
Lithia,	·64 "

so that it contains the three fixed alkalies, but of these potash only in notable quantity.

As the mineral gives off scarcely a trace of water when heated in a glass tube, I obtained an approximate determination of the fluorine which it contains by igniting intensely a portion weighed in a platinum crucible, and calculating from the loss, considered as ter-fluorid of silicon. 17·996 grm. (dried at 250° F.) thus treated lost ·443 grm. = ·3394 grm. of hydro-fluoric acid, or 1·89 p. c. This small percentage of fluorine, and the very small amount of lithia found, both go to prove that the Goshen mica does not belong to the species Lepidolite, but rather to that of Muscovite or common oblique mica.

As a final test of the character of the mineral, it was submitted to optical examination. Professor Benagh of this University was kind enough to measure for me the angle between the optic axes and found it to read about 74°–76°. Prof. Silliman gives 75°–76° for the angle between the axes of the yellowish-green mica which occurs in the same granite vein with this rose-colored mineral at Goshen, and there can I think be little doubt that both are essentially potash-micas of the species Muscovite, the rose-colored being probably tinged by oxyd of manganese.

* Fourth edition, vol. ii. p. 227.

ART. XX.—*Results of some Analyses made for the Geological Survey of the State of Alabama;* by J. W. MALLET, Ph.D., Professor of Chemistry in University of Alabama.

A LARGE number of analyses have been made of specimens collected by those in charge of the field-work of the Geological Survey of Alabama under the direction of Professor Tuomey, State Geologist, but the value of most of these is of a technical or agricultural character, and the results will appear most appropriately in the Report upon the State Survey. It is intended in the present paper merely to extract a few analyses which seem to possess a distinct scientific interest, and to notice very briefly their results.

A *marble* of a delicate pale pink color, from Talladaga Co., was found to contain

Carbonate of lime,	35·67
Carbonate of magnesia,	2·51
Alumina (with trace of Fe^2O^3),	·39
Insol. matter,	61·15
	99·72

and the portion undissolved (by muriatic acid) was fluxed with carbonate of soda, and gave—

		Atoms.	
Silica,	63·67	1·406	5·6
Magnesia,	30·24	1·512	6·
Alumina,	2·05		
Peroxyd of iron,	·39		
Lime,	*trace*		
Oxyd of manganese,	*trace*		
Water,	3·34	·371	1·5
	99·69		

The sp. gr. of this insoluble matter was 2·626, and it is obviously a talc or steatite, which is found intimately mingled with the carbonate of lime of the marble. The latter is very homogeneous in appearance, but derives a slight greasy lustre (and feel to the fingers) from the presence of this steatitic mineral.

Three careful analyses were made of the "*prairie*" or "*rotten*" *limestone* of the Cretaceous formation, from the disintegration of which rock, some of the richest soils of the south are derived. The results were as follows:

		1.	2.	3.
Sol. in HCl.	Carbonate of lime,	75·07	80·48	64·37
	Carbonate of magnesia,	·72	·53	·79
	Peroxyd of iron,	1·44	1·24	2·19
	Alumina,	·79	·98	·75
	Phosphate of lime ($3CaO, Po^5$),	·4035	·3710	·5432
	Silica,	·14	·194	·059
Insol. in HCl.	Silica,	11·99	9·04	19·58
	Alumina,	3·38	2·19	3·97
	Peroxyd of iron,	1·84	1·55	2·49
	Lime,	1·47	1·01	·78
	Magnesia,	——	——	*trace*
	Potash,	·0945	·1135	·0410
	Water,	2·49	2·22	3·58
		99·83	99·91	99·14

No. 1 was from Demopolis; its sp. gr. =1·976 (containing air between its particles). No. 2 was from Jones Bluff on the Tombigbee River; sp. gr. =2·064. No. 3 from Cahawba; sp. gr. = 1·923. The alkali, which was sought for with particular care, was determined for the whole mass of the limestone, but is set down in the above statement of results amongst the constituents insoluble in muriatic acid, as being supposed to be in combination with silica.

The *Greensand* of Alabama has also been examined with reference to its agricultural value and the content of several greensand marls in phosphoric acid, potash, and lime, has been determined. The greensand grains do not often occur of sufficient size and purity for separate analysis, but the composition of those from two localities has been ascertained, and may possess some interest as enabling us to compare the mineral as found here with that of New Jersey and other Atlantic states.

Picked greensand grains from Coal Bluff on the Alabama River gave as the mean of two analyses—

Silica,	57·56
Alumina,	6·56
Protoxyd of iron,	20·13
Lime,	1·04
Magnesia,	1·70
Potash,	4·88
Water,	8·17
	100·04

and another analysis of a specimen from the same locality gave

Silica,	58·91	(of which 11·85 insol. in carbonate of soda.)
Alumina,	5·48	
Protoxyd of iron,	19·24	
Lime,	·71	
Magnesia,	·87	
Potash,	4·58	
Water,	8·17	
Iron pyrites,	1·46	
	99·42	

Sp. gr. of the grains =2·297.

Another specimen, from Gainsville, sp. gr.=2·349, apparently slightly altered by exposure, yielded

Silica,	58·74	(of which 23·89 insol. in carbonate soda.)
Alumina,	4·71	
Protoxyd of iron,	21·06	(traces as peroxyd.)
Lime,	·92	
Magnesia,	1·48	
Potash,	3·26	
Water,	9·79	
	99·96	

The analyses of the mineral from these two localities agree very well together, and agree also, on the whole, well with the results of Prof. H. D. Rogers* for the greensand of New Jersey —the quantity of silica being somewhat greater in the Alabama mineral, and the proportion of potash less—although these differences are less in reality than appearance, since some of the silica is insoluble in carbonate of soda, and therefore does not exist in combination with the other constituents. If the percentage of silica really belonging to the mineral be thus reduced, the quantity of potash present will of course be proportionally increased, and thus brought nearer the amount found in specimens from New Jersey.

Two fine white *Porcelain Clays* were analyzed. The first, from above Jacksonville, gave the following results, on treatment with strong caustic potash and sulphuric acid alternately, as recommended by Brongniart and Malaguti:

* Report on the Geology of New Jersey, p. 200, et seq.

		Atoms.	
Combined silica,	39·75	·877	1·2
Free silica,	4·85		
Alumina,	38·92	·757	1·
Peroxyd of iron,	·78		
Lime, potash, &c.,	1·03		
Water,	13·38	1·487	2·
Undecomposed mineral,	·90		
	99·61		

The second, from Randolph Co., yielded

		Atoms.	
Combined silica,	19·85	·438	1·
Free silica,	17·44		
Alumina,	31·92	·621	1·4
Peroxyd of iron,	*trace*		
Potash, lime, and magnesia,	·72		
Water,	15·09	1·676	3·8
Undecomposed mineral,	14·28	(of which 7·49 = finely divided quartz.)	
	99·30		

The former of these analyses corresponds nearly to the formula Al^2O^3, SiO^3+2HO, which is that of the greater number of specimens examined by Brogniart and Malaguti, while the latter gives the formula $3Al^2O^3$, $2SiO^3+8HO$, approaching more closely the composition of a clay from Wilmington (Delaware), than that of any other in the list of the above-named experimenters.

A considerable number of *Iron ores* have been analyzed, and among them one may be mentioned as containing a notable amount of titanium. It was a specimen of magnetic iron from near Oak Bowery; sp. gr.=4·827. It was decomposed by fusion with bi-sulphate of potash, and yielded

*	Peroxyd iron,	61·37
*	Sesquioxyd of titanium,	9·21
*	Protoxyd of iron,	28·80
	Magnesia,	·08
	Alumina,	*trace*
	Silica,	·54
		100·

I shall notice but a single other analysis—that of an incrustation from the walls of an iron-furnace in Benton Co. It appeared as a hard solid mass, of a dark grayish green color, and sp. gr. =5·172, and proved to consist of nearly pure oxyd of zinc, as shown by the following analytical results:

* Calculated from 93·37 p. c. of Fe^2O^3, and 10·21 of TiO^2.

Oxyd of zinc,	97·77
Protoxyd of iron,	1·21
Oxyd of manganese,	*trace*
Silica,	·64
Carbon,	·08
	99·70

This incrustation is interesting, since similar accumulations of oxyd of zinc in large quantity during the smelting of iron ores have been noticed before, although they do not seem to occur very frequently. One is mentioned in Prof. H. D. Rogers' 4th Report upon the Geology of Pennsylvania, p. 214. It was from the walls of a furnace in Cumberland Co. (Penn.), and contained in 100 parts, oxyd of zinc 92·48, oxyd of lead 6·48, peroxyd of iron 1·00, carbonaceous matter *trace*, =99·96.

Another similar incrustation, from the mouth of a blast-furnace in Shropshire (England), has been described by Prof. Crace-Calvert,* and contained, oxyd of zinc 93·00, oxyd of iron 2·10, sulphuret of zinc 2·00, carbon 2·45, silica ·45=100·00. The iron ore (clay iron-stone nodules), and the coal employed at the furnace from which this last specimen was taken were found to contain little crystals of zinc-blende, the coal also including little particles of galena. Wishing to ascertain the origin of the Benton Co. incrustation, I carefully tested the iron ores there used for zinc, but without detecting any indication of its presence; possibly the limestone used as flux may be found to contain a little blende diffused through it.

University of Alabama, Nov. 12, 1856.

ART. XXI.—*Note on "Red Sulphur;"* by J. W. MALLET, Ph.D., Professor of Chemistry in the University of Alabama.

IN a paper by M. Ch. Sainte-Claire Deville, published in the *Annales de Chimie et de Physique* for May, 1856, in which the various modifications which sulphur undergoes when heated are considered, the author states that the *red* variety of sulphur can be produced only by subjecting the same mass of this substance *several times* alternately to heat and rapid cooling, the permanent red coloration being never obtained *by one tempering*.

Magnus speaks in the same way of this modification of sulphur in his memoir contained in the number of the same journal for June, 1856.

* Number of the "Chemist" for Sept., 1856, p. 706.

Having observed a few months ago the accidental production, by a single heating, of red sulphur, which retains its color perfectly unchanged up to the present time, I will mention the circumstances under which it was obtained, and the properties which it appears to possess.

Some clean roll-sulphur was melted in a glass evaporating dish for the purpose of exhibiting to students the production of the plastic modification on pouring it while thick and viscid into cold water. A portion was so poured into water, and the remainder was heated up to a higher temperature, so as to show the renewed fluidity of the melted mass. Being forgotten for a few minutes over the lamp, the temperature of the sulphur rose so high that it took fire, and the lamp was then removed, and the flame extinguished by throwing a cloth over the dish.

On examining the sulphur an hour or two after, it was found solidified in a cake of distinctly prismatic crystalline structure, and of a brownish-red color. It was broken up into pieces of a size to go into a bottle, and in the interior were observed some little cavities lined with stout prismatic crystals.

This sulphur, having been set aside for several months, presents just the same appearance now as when first prepared. Its color is nearly chocolate-brown, verging on red, and its hardness is greater than that of common roll sulphur. Re-fused at a gentle heat it forms a thin, very dark brown liquid, appearing almost black by reflected light. If left to cool slowly in the air this solidifies again to a crystalline mass like the original cake, but a little darker in color. If a portion be poured while melted into cold water it forms drops of a deep red color (like Pyrope) by transmitted light, and almost black by reflected light. These drops do not solidify at once but remain soft, so that on touching them with a wire under water they may be drawn out into threads. When perfectly solidified they have a vitreous lustre and the same very dark red color as in the plastic state, resembling somewhat "glass of antimony." They gradually, in the course of two or three days, become in part opaque and of a light red-brown color, this change being confined for the most part to the surface of the drops, of which the interior remains glassy as before, but in some cases extending in veins and striæ through the interior of a drop. The change from the glassy to the opaque state begins usually at distinct points, and spreads gradually over the surface.

A portion of the original cake was melted and poured into cold water ten or twelve times in succession, as in the process for preparing red sulphur of MM. Magnus and Sainte-Claire Deville, but after these numerous heatings and coolings it presented very nearly the same appearance as at first, whether it were examined after slow cooling in the air or rapid solidification in

cold water; it was perhaps rather darker in color than that which had been but once re-melted. It became also slowly opaque and light in color on exposure to the air for two or three days.

Some fragments of the original cake, with prismatic crystals upon them, were treated with bi-sulphuret of carbon. This rapidly dissolved out ordinary sulphur, forming a pale yellow solution, which became brownish orange on heating with the insoluble residue. The solution, allowed to evaporate spontaneously in the air, left octahedral crystals of ordinary yellow sulphur, tinged in places by a very little red, and round the edges of the evaporating dish was an amorphous crust of red sulphur; the quantity of the latter being quite small in proportion to that of the yellow modification dissolved, as observed by Deville and Magnus.

The portion insoluble in bi-sulphuret of carbon was of a red-brown color, and amorphous; it retained in some cases the prismatic form of the crystals in which it had been inclosed, but fell to the bottom of the vessel, on shaking, as a flocculent amorphous powder. A little of this insoluble red sulphur was heated in platinum foil, and burned without any residue.

A fragment of the original cake, heated in a test tube up to the boiling point of sulphur, sublimed, and appeared after sublimation with its ordinary yellow color; the unsublimed part re-solidifying as it cooled with the same red-brown tint as before.

Comparing all these characters with those of the red sulphur obtained by MM. Magnus and Sainte-Claire Deville by *repeated* heatings and coolings, it seems certain that a considerable portion of the same allotropic modification had been produced by a *single* heating in the unintentional experiment mentioned in this note.

ART. XXII.—*Observations upon the Carboniferous Limestones of the Mississippi Valley;** by JAMES HALL. [Abstract.]

THE object of this communication was to show that certain reliable and well marked subdivisions exist in the "*Carboniferous limestone*," as it is usually termed, of the Mississippi valley. The subdivisions heretofore proposed were founded, in part, upon certain supposed characteristic fossils, such as the Archimedes, the Pentremites, etc., which, though reliable as individual species in their geological range, are not, as genera, characteristic of the subdivisions. The subdivisions proposed in the report of Dr.

* From the Proceedings of the American Association for the Advancement of Science. The same subject essentially forms a part of the Report of Progress of the Iowa Geological Survey.

D. D. Owen are, first, an upper and lower series, each of which is again subdivided into several distinct beds or groups. For the sake of comparison, this table of Dr. Owen's is here given.

"SECTION OF SUB-CARBONIFEROUS LIMESTONES OF IOWA.

	Coal Measures.
20 feet.	Upper concretionary limestone.
10 feet.	Gritstones.
30 feet.	Lower concretionary limestones.
10 feet.	Gritstones.
10 feet.	Magnesian limestone.
30 feet.	Geodiferous beds.
50 feet.	Archimedes limestone.
15 feet.	Shell beds.
15 feet.	Keokuk cherty limestone.
70 feet.	Reddish brown encrinital group of Hannibal.
55 feet.	Encrinital group of Burlington.
75 feet.	Argillo-calcareous group, Evans' Falls."

The above expresses the measurements and succession of the rocks as given in Dr. Owen's section.

Prof. Swallow, in his Report on the Geological Survey of Missouri, subdivides the Carboniferous limestones and rocks below the lower coal measures as follows:

Carboniferous limestone.	E. Lower coal measures,	140 feet.
	F. Ferruginous sandstone,	195 "
	G. St. Louis limestone,	250 "
	H. Archimedes limestone,	200 "
	I. Encrinal limestone,	500 "
Chemung group.	J. Chouteau limestone,	70 "
	K. Vermicular sandstones and shales,	75 "
	L. Lithographic limestones,	60 "

Under each of these divisions are given numerous localities where the rock is well developed.

In descending the Mississippi river, we come upon the lowest and most northerly outcrop of these limestones at Burlington, Iowa. At this locality we have the following section, in the descending order.

1. Encrinal limestone.
2. Oolitic limestone, fossiliferous.
3. Compact arenaceous limestone.
4. Fine grained argillaceous sandstone or grit stone, with casts of Spirifer, Chonetes, Productus, Bellerophon, Orthoceras, etc.
5. Green shale.

The entire thickness of 2, 3, 4, and 5, is about 70 to 80 feet; the base of the green shale however has not been observed.

These members constitute the argillo-calcareous group of Evans' Falls, in Dr. Owen's section, and the members J, K, and L, of Prof. Swallow's section. The higher beds belong to the age of the Chemung group, containing the same fossils as the rocks of that group in New York and elsewhere, and have been carefully traced throughout the intermediate space. It is quite probable that, in strict parallelism, the green shale of Burlington and Evans' Falls, which weathers to an "ash colored earthy marlite," should be referred to the Portage group, since here it lies between well marked Hamilton beds and the Chemung. And it is likewise probable that the Lithographic limestone of Prof. Swallow will be found more closely allied to the Hamilton than to the Chemung group.

We have however in the light colored, friable sandstones of the Chemung group a well marked and reliable horizon. The oolitic bed is more allied by its fossils with the Chemung below, than with the encrinital limestones above; though between the latter there is often no well marked physical line; so gradual and imperceptible is the change from what is termed Devonian to the acknowledged Carboniferous rocks.

The encrinital limestone of Burlington, or, as we shall hereafter term it, the *Burlington limestone*, is characterized by its great numbers of crinoids, of which Drs. D. D. Owen and B. F. Shumard have described numerous species. The rock is in a great measure composed of the broken and comminuted remains of this family of fossils: large masses of the rock consist almost entirely of the separated but unbroken joints of the columns of various species.

This rock includes the "Encrinital group of Burlington," and the "Reddish brown Encrinital group of Hannibal," in Missouri of Dr. Owen's section; the latter being in no respect different from the former, and holds precisely the same position in the series, having the same beds above and below. The "Encrinital limestone" of the Missouri report is likewise identical with the Burlington limestone, and is so recognized by Prof. Swallow.

The Burlington limestone is succeeded by cherty beds with intercalated beds of light gray limestone. These have a thickness altogether of sixty to seventy-five feet, and constitute the beds of passage to the next division of the limestones. The cherty beds form the rapids above Keokuk, so well known in the navigation of the Mississippi river. These are termed by Dr. Owen the Keokuk cherty limestones. The so-called silicecous formation of Tennessee and Alabama are of the same strata.

The second important limestone is recognized in the sections both of Prof. Swallow and Dr. D. D. Owen as the "*Archimedes limestone*," from containing a bryozoan of the genus *Fenestella*, with a spiral axis,—the *Archimedes* of Lesueur.*

On descending the Mississippi river, this limestone is found at Dallas, at Appanoose, and opposite to Madison, and at Nauvoo, Ill., and is largely developed at Keokuk; the shell beds of Dr. Owen forming a subordinate member of the mass. The *Archimedes* is extremely rare in all these localities, as well as at Quincy, Ill., where the lower part of the rock is seen resting on the cherty beds which separate it from the Burlington limestone.

This limestone which may for convenience be termed the Lower Archimedes limestone or Keokuk limestone, contains numerous characteristic fossils. In the upper part the *Archimedes* occurs sparingly, with *Cyathophylla*, *Spirifer striatus*, *fish teeth*, etc. Among the crinoids are *Platycrinus Saffordii*, *Actinocrinus Humboldtii*, *Agaricocrinus tuberosus*, and others.

The Keokuk limestone is limited above by a mass of shales or marls with impure limestones, known locally as the "*Geode bed*," from the numerous geodes, lined with quartz crystals, chalcedony, calc spar, etc. which it contains, and which have been distributed very widely throughout the United States. This

* See observations upon the genus Archimedes or Fenestella, following this article.

mass constitutes the "Geodiferous beds" of Dr. Owen's section, but has not been recognized in the Missouri section.

Succeeding the geode bed, and recognized in the same localities near Warsaw, Ill., at Appanoose, and other places, is a bed of magnesian limestone, given in Dr. Owen's section under the same name.

To the magnesian bed, which has a thickness of some ten feet, and is doubtless only of local development, succeeds a series of beds of blue marlites, with intercalations of impure limestones, or in some places of impure limestones separated by seams of blue marlite. The upper portions become arenaceous, and sometimes contain small pebbles, forming the gritstone of Dr. Owen's section. The central and principal portion is highly fossiliferous, abounding in reticulated bryozoa; and among these the axis of a species of *Archimedes* occurs in great numbers and of extraordinary size and perfection. So abundant is it that a dozen individuals may sometimes be seen in the space of a few feet. The species is quite different from the one in the Keokuk beds, being more robust and the volutions of the spiral axis less rapidly ascending.

This *second* Archimedes limestone seems not to have been recognized in the section of Dr. Owen; and judging from localities cited, it appears to have been confounded with the *lower* Archimedes or Keokuk limestone. The position however of the Warsaw Archimedes limestone is above the geode bed, the *Archimedes* is a distinct species and it is associated with several species of crinoids, fish teeth, etc., which do not occur in the lower beds.

The arenaceous bed which terminates this group, and which likewise contains *Archimedes* and joints of crinoidal columns, is succeeded by a light gray, compact limestone, which is often concretionary or brecciated in its structure. Its most conspicuous fossil in many localities is *Lithostrotion floriforme*.

This limestone is termed by Dr. Owen the "concretionary limestone," and by Prof. Swallow the "St. Louis limestone."* It is the same rock which forms the low cliff below Keokuk, near the mouth of the Desmoines river at St. Francisville, Mo.; the greater part of the bluffs of the river for some distance above Alton, Ill.; the limestone of St. Louis in whole or in part; the limestone of St. Genevieve; the limestone of Prairie du Rocher, Ill.; and in part, the bluffs bordering the American Bottom, below Alton, Ill.

At this point the sections both of Dr. Owen and Prof. Swallow cease, so far as limestones are designated. The Concretion-

* After a careful examination of the locality cited by Dr. Owen, I am unable to find a second concretionary limestone, though it is not difficult to see how such an error should have occurred in measuring the section near the mouth of the Desmoines river.

ary limestone of Dr. Owen is succeeded by sandstones and shales of the coal measures, which is the true order at the mouth of the Desmoines and other places, but not universally true. In the section of Prof. Swallow, the St. Louis limestone (Concretionary limestone of Owen) is shown to be succeeded by a brown or ferruginous sandstone, F, of section of Missouri report, and upon this rests the lower coal measures. This order is likewise true of some parts of Missouri and of Illinois, but it is not everywhere true in these states.

The ferruginous sandstone is in turn succeeded by an extensive and important limestone formation, consisting of beds of limestone of greater or less thickness alternating with thin seams of marl or shale, and in some parts heavy bedded limestone of considerable thickness, without shaly partings or with very thin ones. The group embraces likewise one or more heavy sandstone beds, and a mass of green shale or marl more than fifty feet thick.

This formation constitutes the limestones of Kaskaskia and Chester, Ill., and those below St. Genevieve in Missouri. They occur at other places on the river, and form the greater part of the limestones of southern Illinois and Indiana, and those of Kentucky. This limestone is likewise known as the Archimedes limestone and sometimes as the Pentremital limestone, from the abundance of its Pentremites. It has evidently been always confounded with the lower Archimedes or Keokuk limestone, as is shown by the citation of localities in the reports above mentioned, and in other publications upon western geology.

The species of Archimedes which it contains in great numbers is quite distinct from the other two named, and the character of its axis alone is sufficient to distinguish the rock from either of the lower ones. The stratigraphical position of this rock is most clearly defined and readily determinable. The assemblage of fossils is distinct from all those in the rocks below, and there remains no reason for confounding it with either of the other divisions.

In following down the course of the Mississippi river, the St. Louis limestone is seen to pass beneath the ferruginous sandstone F, and upon the latter rests the limestone group of Kaskaskia and Chester in Illinois, and of St. Mary's in Missouri.

From these data we are prepared to show the true order of the successive beds among the Carboniferous limestones of the Mississippi valley; and also in Indiana, Kentucky, Tennessee and Alabama.

The following section illustrates the preceding statements regarding the order of superposition among the different members of the limestone series.

VII.	Coal measures.	
VI.	Kaskaskia limestone, or Upper Archimedes limestone,	Kaskaskia and Chester, Ill. St. Mary's, Missouri, etc.
V.	Gray, brown or ferruginous sandstone, overlying the limestones of Alton and St. Louis,	Below St. Genevieve, Mo. Between Prairie du Rocher and Kaskaskia, Ill.
IV.	"St. Louis limestone," or "Concretionary limestone."	St. Louis; highest beds below Keokuk. Alton; St. Genevieve.
III.	"Arenaceous bed," Warsaw or Second Archimedes limestone, "Magnesian limestone,"	Warsaw and above Alton, Ill. Keokuk, Iowa. Spergen Hill, Bloomington, Ia.
	Beds of passage, soft shaly or marly bed with geodes of quartz, chalcedony, etc.	
II.	Keokuk limestone, or Lower Archimedes limestone,	Keokuk, Quincy, Ill., etc.
	Beds of passage, cherty beds 60 to 100 feet.—Rapids above Keokuk.	
I.	Burlington limestone,	Burlington, Iowa; Quincy, Ill.; Hannibal, etc., Missouri.
	Oolitic limestone and argillaceous sandstone of the age of the Chemung group of New York.	Burlington, Iowa. Evans Falls. Hannibal, Mo.

The difficulties which have occurred in the way of a reconciliation of the views of Western geologists have arisen in great part from the fact that these different limestones have not an equal geographical distribution; there being no point on the Mississippi within our knowledge where a section at right angles to this valley will embrace all the beds here enumerated. The limestones likewise change their character when examined in a north and south direction, owing to causes which will be explained. The fossil forms which have mainly been relied upon for characterizing the divisions have been to a considerable extent of generic value only; and specific differences have not always been properly recognized.

In the geographical distribution and the changes of lithological character at different points we have yet much to learn. These groups of limestone have been successively deposited in an ocean which was gradually contracting its limits upon the north. The lowest or Burlington limestone has therefore a greater extension northward than either of the succeeding groups; and its gradually thinning edges stretch far towards Iowa city, near which latitude was the northern boundary of the ocean, or at least the limit of its animal life. Considerably to the southward of this, we first find the attenuated northern edges of the Keokuk limestone, mingled with much earthy sediment, and often consisting of a few thin beds of Encrinal lime-

stone intercalated among other beds of an argillaceous character. It is only farther south, in the neighborhood of Nauvoo and Keokuk, that this limestone first exhibits decidedly its characteristic features. The limits of the ocean admitting of rock deposition at this period never extended so far north by many miles as in the period of the Burlington limestone.

The Warsaw Archimedes limestone appears to have been nearly coextensive with that below, so far as known at present. The St. Louis limestone extends northward also, nearly or quite to the same limit, but only in a thin brecciated or conglomeratic mass which has been rarely recognized above the lower rapids of the Mississippi. It is only on descending the valley to the neighborhood of Alton that this rock appears in any considerable force.

To these limestones succeeds the sedimentary deposit of ferruginous sandstone, which in the river valley is not known far to the north of St. Louis, while the succeeding Kaskaskia limestone becomes important in the vicinity of the Kaskaskia river, and is known in the interior as far north as Prairie de Long, and increases in force as we go southward.

We have most clearly therefore the evidence that the limits of the ocean admitting of calcareous deposits was gradually contracting, at least in the direction from north to south, leaving the more southern portions as the areas of greatest development for these limestones.

Some interesting inquiries are suggested by these facts, and at the same time they afford in some degree the solution of a difficulty which has heretofore been unexplained.

It is well known that no limestone of the age of those here described, occurs beneath the coal measures on the western side of the Appalachian coal field north of the Ohio river; nor upon the eastern side of the same field, till we reach the central part of Virginia. The same is true of the coal fields of Nova Scotia and New Brunswick according to Prof. Dawson, the northern sides exhibiting no underlying limestones, while these rocks do appear coming out from beneath the coal measures on the southeastern side. The same phenomena occur in regard to the northern portions of the Illinois and Iowa coal basins.

At the same time I have ascertained in the most satisfactory manner that the coal fields of Iowa, Missouri and Illinois, rest unconformably upon the strata beneath, whether these strata be the Carboniferous limestones, the Devonian, the Upper Silurian, or the Lower Silurian rocks. In either case the measures are unconformable, differing only in degree.

It would appear, that at a period long preceding the commencement of the carboniferous limestone deposits, the ancient ocean began to contract its area; that this contraction was due to

the uplifting of the older rocks upon the north; and that this state of things continued throughout all the period of the limestone deposits. It would also appear, that during this period or at its close, and previous to the deposition of the coal measures, the older strata, becoming uplifted and at some points broken by faults, acquired in many places an inclination of from ten to thirty degrees; that denudation to some extent wore down the inequality caused by this uplifting agency, and produced other irregularities of the surface.

The coal measures extend much farther to the north than the northern limits of the Carboniferous limestones, and are spread out over the thinning and slightly inclined edges of these beds, and over the more disturbed and more highly elevated edges of the rocks of the preceding periods; so that the coal measures rest respectively upon all the formations from *lower Silurian* to the *Carboniferous limestones.* The only explanation we can offer is that the area of the ocean which had contracted up to the time of the coal period, was afterwards extended by the sinking of the land, allowing the sandstones and shales of the coal measures as well as subordinate beds of limestone, to be spread over much wider areas than the preceding formations of carboniferous limestone.

This accounts for the absence of the carboniferous limestones on the northern margins of all the coal fields.

It is true however that the carboniferous limestones of Nova Scotia have a more northerly extension than the northern limits of the Appalachian coal field; but if these limestones of Nova Scotia be of the same age as those at the southwest, their occurrence there may be due to the direction of the ancient sea margin or the line of ancient coral reefs. It appears that this direction may have been from the southwest to the northeast, at least for that portion of country east of the Cincinnati axis; while to the west of that line the carboniferous limestones make a northerly bend, as if at that period that part of the ocean now the valley of the Mississippi admitted of a greater extension of the coral reefs in that direction.

This view, sustained by facts, while it offers a general solution of the difficulty respecting the non-occurrence of carboniferous limestones on the northern margins of all the coal measures, at the same time suggests an explanation of the greater accumulation of conglomerates and coarse materials in the same position.

The high angle of elevation of the older strata, and the inequalities of surface on which the western coal measures rest, prove conclusively that extensive denudation had taken place previous to the coal period; and this fact should suggest a caution in our conclusions regarding the vast influence of modern denudation upon the surface of the globe.

Among the remarkable and interesting consequences of this ancient denudation, it is not uncommon to find depressions among the inclined strata of the Silurian rocks, filled with regular coal deposits, lying usually nearly horizontal or with a slight dip varying from the surrounding rock. These outcrops which sometimes occur in ravines or the valleys of water courses have all the aspect of regular coal measures; from the direction of the bedding they would penetrate the bank, but are nevertheless cut off by the inclined strata frequently within a few yards. Isolated masses of this kind are not uncommon, both in Iowa, Illinois and Missouri, lying at the foot of elevations and apparently penetrating the adjoining higher ground. These in many instances in Missouri have been worked entirely out, and proved to have no connexion whatever with the adjoining beds, or with any other coal in the vicinity.

In several localities on the Mississippi in Iowa, the older rocks dip to the northward at an angle of from ten to fifteen degrees, presenting the outcropping edges at points more or less distant from each other, while the intermediate space is occupied by strata of the coal measures, lying in a horizontal position. These phenomena have been mistaken for faults, but their origin is far different; and the coal measures have apparently never been disturbed from the time of their deposition.

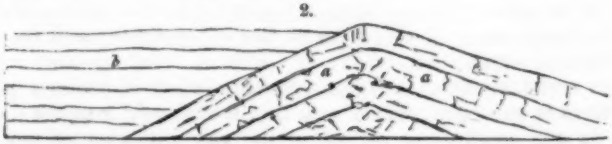
Among the examples of this kind may be noticed more than one between Davenport and Le Claire. Within three miles of the latter place the strata of upper Silurian limestones dip to the northward, and between two points of outcrop, the horizontal beds of coal shales, sandstones and iron ore, occupy the space, thus:

1.

a, *a*, outcrops of Silurian limestone as seen above the level of the river, dipping to the northeast.
b, *b*, coal shales and sandstones lying in a horizontal position.

In another instance the coal measures present the following relations to the underlying rocks:

2.

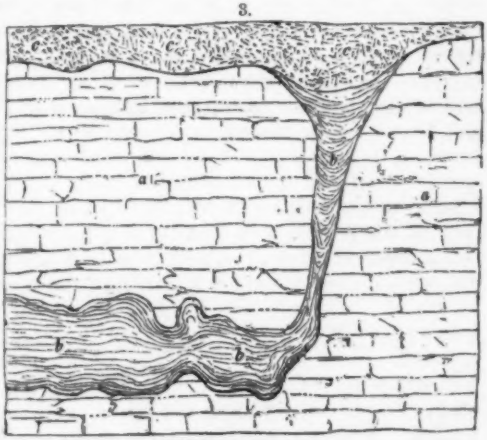


a, *a*, axis of Silurian limestone.
b, horizontal coal measure strata traced to within three feet of actual contact with the limestones which dip at an angle of 30°.

A still more interesting exhibition of phenomena attendant upon this condition of the strata, and consequent upon this ancient denudation, is the occurrence, in the limestones of the age of the Hamilton and Upper Helderberg groups, of rounded or irregular masses of clay, like the underclay of coal seams. These masses which are seen in sections along the river, and in quarries, often present simply the appearance of a spheroidal mass of clay, sometimes a narrow seam of clay connects this mass with a similar one in a higher bed of limestone; and it not unfrequently happens that these clay seams, which are always vertical to the bedding of the limestone, may be traced to the surface, where the clay mingles with the superincumbent materials of the drift, as if having the same origin. On examining the parts of contact between the clay and limestone, we find the former adhering closely, and when separated, the limestone still retains a striated coating of the clay. The clay is laminated, and the laminations are curved or irregular, but never parallel to the lines of bedding in the limestone.

A single instance of this character satisfied me that these masses of clay were of subsequent deposition to the limestone, and that they filled cavities which had been made by denudation like modern caverns in limestone. This example was seen in the vertical face of a quarry presenting an elevation of 30 or 40 feet. From the loose soil above is a depression at the surface of the limestone; this is the commencement of a broad funnel-shaped opening, which gradually narrows below till within 10 feet of the bottom, where it spreads out on one side; having an irregular arching roof with numerous small archings and an unequal floor. Its extension to the left had been in part cut off. This cavity from top to bottom is filled with hard clay like the underclay of coal seams. At the mouth of the funnel it is of a reddish brown hue, but soon becomes of the ordinary gray

3.



a, a, a, Limestone of Devonian age.
b, b, b, Ash colored clay, similar to the underclay of a coal seam.
c, c, c, Gravel and yellowish colored loam.

color below.* The laminations of this clay, in the upper part, conform to the curvatures and irregularities of the roof of the ancient cavern, and exhibit every appearance of having flowed in while in a semi-fluid condition; while the hydrostatic pressure of the mass above, operating through the deep funnel, had forced the soft mass against the roof, causing it to assume in its laminations the same curvatures and irregularities.

In the midst of this mass of clay, was seen the impression of a large Euomphalus, quite distinct from any fossil known in the surrounding rock, and very similar to a carboniferous form. The shell itself was not seen. With this exception, no remains of fossils were observed in the clay at this locality.

It seems impossible therefore to resist the conclusion, that subsequent to the uplifting of these rocks, the denudation of their surfaces and the wearing into caverns, the materials of the coal measures were distributed, filling these cavities, and depositing the successive members of the coal series upon the surface of these older rocks.

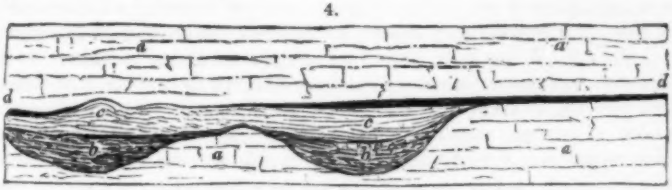
If anything were wanting to complete the chain of facts, and carry the most conclusive evidence, it is found in a section near Iowa city. In a cliff of limestone, of the age of the Upper Helderberg of New York, where the strata are nearly horizontal, we have the following phenomena.—Along the line of separation between two beds of limestone appears a black band extending for thirty or forty feet; beneath this, and of less horizontal extent, is a thicker layer of clay, precisely like that of the cavities before described, and of the character of underclay; still below this, and occupying the depth of the cavity is a coarse sandstone. This sandstone follows in its lines of lamination or bedding the curvatures of the limestone upon which it lies, gradually filling up the cavity, and extending its laminæ above. Upon this comes the underclay filling the upper and broader part of the cavity, and having a greater horizontal extent than the sandstone below. Above this underclay, stretching for several yards upon each side and filling the open seam between the layers of limestone, is a band of black carbonaceous mud, the lower part slaty, and the upper part having the character of *cannel coal*. Here we have all the phenomena attending a coal-measure seam of coal. The sandstone, the underclay, and the seam of coal resting upon the latter, and, as if to complete the analogy, the slaty portion of the seam contains *fish teeth* of carboniferous character. All this is enclosed in limestones, which, in the state of New York, where the series is more complete, lie at a depth of more than 5000 feet below the coal measures.

In this instance the explanation is clear enough. It is only a little more perfect in its members than the preceding case, and

* The reddish brown color is simply due to infiltration from the ferruginous drift above.

the aperture of admission is not visible in the same exposure. The coarse and fine sand were first transported, and falling through the fissure in the rock, continued in deposition in this cavity, while a bed of similar sandstone was being formed outside, and upon the bed of the sea. This ceased, and then came the clay which was continued in like manner, while the underclay of an exterior coal bed was in process of deposition. Lastly the carbonaceous mud derived from a coal seam, or the materials forming one, were filtered through the fissure and spread out in the narrow seam below.

4.



a, a, a, a, Limestone of Devonian age.
b, b, Coarse sandstone in curved laminæ.
c. c, Ash colored and greenish ash colored underclay.
d, d, Coal seam with shaly mud containing fish teeth.

There has been no mingling of the materials as if resulting from the breaking up of a coal seam at a later and modern period, and the subsequent filtration through a seam into this rock. Every part is as distinct as in the coal measures elsewhere; and it could only have resulted from a participation in the causes then operating to produce those extensive beds of sand, clay, shale, and coal, which make up the coal measures.

It should not be forgotten that this point is near the northeastern margin of the coal measures, and beyond the limits of any known productive coal seam; a few isolated patches of sandstone and shale being all the remaining evidences of the extension of this series in that vicinity.

The fissures and caves occupied by the lead ores in Wisconsin, Illinois, Iowa and Missouri are apparently of similar character and origin; the period of their production, being a point of discussion. Whatever may be said to the contrary, it appears still very certain that these lead-bearing fissures have no connexion with the rock below; and also that the character of the fissures, with the materials filling them, indicates an action from above. That these cavities were excavated, and subsequently filled or partially filled with the ores of lead, zinc and iron, by infiltration from above, seems, as elsewhere stated by the writer,* as well settled a problem, as that the coal seam just noticed is due to infiltration from above. The age of the rock in which the lead

* The same views, in reference to the origin of the lead ores, are entertained and have been published by Mr. J. D. Whitney.

occurs is not a question affecting the origin of the mineral matter, for while in Iowa, Wisconsin and Illinois the lead-bearing rock is an upper member of the Trenton limestone period, it is in Missouri the Calciferous sandstone, a rock much older than the Trenton period. The mode of occurrence of the ore is similar in both places.

The fact that the calciferous sandstone in Missouri is the lead-bearing rock, and that sometimes in Upper Iowa and Wisconsin the same rock contains some lead ore, has induced the belief that the origin of the ore is from below. It is true that the Calciferous sandstone is spread over large areas of country on the north of the productive lead region of Illinois, Iowa and Wisconsin; but thus far it has been found to contain no lodes of value. It is likewise less cavernous than the lead-bearing or Galena limestone, and far less so than the same rock in Missouri. From what we know, it appears that neither the Carboniferous limestone nor the coal measures ever reached so far north as the northern lead-bearing rock, while these strata occupy the country around the lead region of Missouri, and outliers of the coal measures often rest directly on the Calciferous sandstone, the lead-bearing rock of that State.

There is therefore strong presumption in favor of regarding these fissures and caverns, whether filled with mineral matter or otherwise, as having been formed during the Carboniferous period, and previous to the deposition of the coal.*

The elevating forces which have raised the pre-carboniferous strata to their present inclination throughout the west, have had a determinate direction, and this direction has been from northwest to southeast, parallel to the great mountain ranges on the west and at a nearly right angle with the great Appalachian chain on the east. So far as my opportunities permitted the determination of the direction, it is north 40° or more west.

In descending the Mississippi river we first notice that the strata rise and fall in broad undulations, which cross the direction of the valley from northwest to southeast. Still lower down we meet with more abrupt anticlinal axes, and in one of these at the Upper Rapids and below are several minor plications. Below Davenport we find considerable regularity; and between

* In making this statement, the writer would not be understood to say that similar fissures and caverns may not have been produced in these rocks during the modern or intermediate periods, through the drift and other degrading agencies, which at the same time may have removed the clay or other mineral matter from caverns of previous date, rendering the determination of the period of their origin, a matter of considerable difficulty. At the same time, the fissures filled with mineral matter, accompanied or unaccompanied by a peculiar clay quite different from the drift materials of the region, or with this clay alone, or with indurated clay like the underclay of coal seams, either with or without the presence of sandstone and coal, all point to a period long anterior to that of the modern drift.

that point and Cap au Gris we again notice only broad undulations, which reveal successively all the strata from the Carboniferous limestone to the lower Silurian rocks. In approaching Cap au Gris from the north, there is a gradual rising of the lower strata, so that the Trenton limestone is beautifully defined for a considerable distance; and beneath it lies a magnesian limestone, apparently of no great thickness. The dip to the northeast increases, and from beneath these limestones, the sandstone rises in a bold escarpment continuing for three-fourths of a mile, and presenting several hundred feet of thickness. This elevation suddenly declines to the southward, and we find the Burlington or lower Carboniferous limestone standing vertically by the side of the lower sandstone. The limestone soon assumes a steep and gradually a more gentle dip to the south, and the succeeding members come in successively. This fault, which is in fact an anticlinal axis, has a northwest and southeast direction, and, according to the observations of Mr. Worthen, extends far into Illinois.

Below St. Louis, in the vicinity of Selma, there is another decided anticlinal axis, bringing up the lower sandstone. According to the Missouri Report the lower limestones and sandstones are again brought up in the vicinity of Bailey's Landing; but I have personally examined the strata at this place only so far as to decide that the Upper Silurian strata appear from beneath the Upper Helderberg and Hamilton groups, beyond which the Carboniferous limestones appear to come on unconformably in the synclinal axis.

Still another axis of very decided character brings up the Trenton limestone in great force at Cape Girardeau on the Missouri side, and at Orchard Creek below Thebes on the Illinois side. This axis affects all the southern portion of Illinois below a line drawn from Fountain Bluff on the Mississippi to near Golconda on the Ohio. In some parts of its course this axis would appear to deviate from the meridian no more than 35° west of north and 35° east of south. In a country however, where denudation has taken place to such an extent, and succeeding strata are spread over the uplifted edges of those below, it is not always easy to determine the exact direction until traced over a wide extent.

That these low axes crossing the Mississippi are the results of the great movement which elevated the fundamental strata of the western mountain chain, we can have little doubt. The forces that there acted upon the huge pile of sedimentary strata, raising them into high mountain chains, here operated upon a thickness of a few hundred feet; and we may have not only the dying out of the elevating force, but also the diminished thickness

of the strata for the subject of its action. If the action which elevated the great mountain chains of the west operated only on the palæozoic strata, the greater amount of material in that direction would give greater elevation to the ridges, which under similar force would die out in the Mississippi valley for want of material to be elevated.

The discussion of this part of the subject however does not properly enter into the present paper, and will be postponed to another occasion.*

A few words may express the general features of the series of these limestones on the south of the Ohio. All the members, with the exception of the higher or Kaskaskia limestone, gradually thin out to the south.

The "*Siliceous group*," as it is termed in the Geological Report of Tennessee, there lies at the base of the Carboniferous limestone. This group is simply an extension of the cherty beds lying between the Burlington and Keokuk limestones, and which become largely developed in the south. The Burlington limestone is rarely seen occupying a few feet of thickness beneath the "siliceous group," and is usually not recognized as a distinct mass. The Keokuk, Warsaw, and St. Louis limestones have thinned out so far as to form no important feature in the series; while the Kaskaskia limestone predominates over the whole country, and is there the great "Carboniferous limestone," yielding its abundance of Pentremites and Crinoids throughout its extent in Tennessee and Alabama.

Note.—So far as known to the writer, the first notice of the unconformity of the western coal measures with the older rocks was brought out at the Providence meeting of the American Association for the Advancement of Science, in a discussion upon a section of the coal measures of northern Illinois, presented by Edward Daniels, Esq. This gentleman afterwards visited and re-examined the locality, and communicated to me the following section, as confirmatory of the views I had there expressed. The communication bears date of November, 1855.

5.

a, Calciferous sandstone; *b*, St. Peter's sandstone; *c*, Trenton and Galena limestone; *d*, Coal measures resting unconformably upon the rocks below.

* See Introduction to Vol. III. Palæontology of New York.

I may remark in this place that the observations made and the collections brought home by Capt. Stansbury from the Salt Lake region, demonstrated that the *upper* carboniferous limestone, in an unaltered or scarcely changed condition, and bearing numerous fossils, rests unconformably upon metamorphic rocks of older date, corresponding with what is so well shown in the Mississippi valley. The topography accompanying these observations also shows that these mountains of limestone have a nearly north and south direction, corresponding doubtless with the direction of the fundamental axes of the country.

In a "Report upon the Mineral Resources of the Illinois Central Railroad, by J. W. Foster," published in 1856, a section similar to the one above is given; and the credit of the discovery of the relative position of the two series of rocks is there attributed to Dr. Norwood, the geologist of Illinois. It is certainly probable that Dr. Norwood has been aware of this fact for a long time, and the writer, in common with many of his friends, has had occasion to regret that Dr. Norwood has not long since published some portion of the accumulated facts of many years of investigation.

Although aware for several years of this relative position of the lower rocks and the coal measures, yet I was never fully impressed with the high interest and importance of the matter, until I had carefully followed out the successive members of the Carboniferous limestone series. Disclaiming any desire to appropriate the discoveries of others, the writer has presented in the preceding paper the facts that came under his own observation, and the conclusions which seemed legitimately deducible therefrom.

I should do injustice to my own feelings were I not in this place to acknowledge the valuable aid rendered to me by Mr. A. H. Worthen, my assistant in the Iowa Geological Survey, whose intimate knowledge of the principal localities of the carboniferous limestones in the Mississippi valley enabled me to accomplish my investigations in much less time and with far more satisfaction than I should otherwise have been able to do in a single season. We explored together these formations as far as the mouth of the Ohio, after which Mr. Worthen carried on, under my direction, the observations through Tennessee and Alabama, with a view to the recognition of the groups established in the investigations in Iowa, Illinois and Missouri.

ART. XXIII.—*Remarks upon the Genus Archimedes or Fenestella from the Carboniferous Limestones of the Mississippi Valley;* by JAMES HALL.

THE term *Archimedes* has long been in use among American geologists, and is the generic name given by Lesueur to a Bryozoan, which consists of broad reticulate expansions, thickening at their base, and spirally arranged around an elongated axis or stem, or, perhaps more properly the thickened base forms the axis. The axis is solid or irregularly cellular in its interior structure, the expanded portions have the general character of *Fenestella* upon the lower or external side, while the upper or inner side is in like manner celluliferous. The cellules are cylindrical with circular or sub-circular mouths, arranged along the branches in two or more rows; the branches are rounded or angular above, connected by transverse processes, leaving oval or subquadrangular interstices.

In all the essential characters, the foliate expansions of *Archimedes*, correspond to *Fenestella*, according to the extended description of this genus given by Mr. Lonsdale, and in detached fragments it cannot generally be distinguished from other forms of the same genus. Some of the species have more than a double row of cells on the branches, and correspond to the genus Polypora of McCoy, but nevertheless this character is found in true Fenestellæ as above cited.

The mode of growth therefore, constitutes the only reliable character for separating *Archimedes* from *Fenestella*, and should this be hereafter considered of sufficient importance, I propose to retain the original name of Lesueur, "Archimedes," for fossils having this character.

Dr. D. D. Owen has several times alluded to "Archimedes" in his various reports; and in a paper published in the American Journal of Science and Arts, vol. xliii, p. 19, he gives a figure of one of the species as the "Archimedes of Lesueur," but suggests that it may be only a new species of Retepora. This figure of Dr. Owen is of a large species; but being merely the spiral axis it furnishes no character for specific identification. It retains the thickened base of the foliate expansion, and where this is broken through presents the irregularly cellular structure common to the axis of all the species.

This structural character or the remains of the fenestrules on the edge of the spire, as seen in the figure, have been mistaken by M. D'Orbigny for the animal cells, and upon this character he proposes a new genus *Archimedipora* having the cells arranged upon the salient angles of the spiral band, and places the fossil in the Devonian system. It is scarcely necessary to say that no such fossil is known in the Devonian system in this country, up to the present time.

The description of M. D'Orbigny is as follows: "cellules longues placées aux angles saillents d'une spirale autour d'une tige allongée."

It is quite unnecessary to say that the "*Archimedes*" of the carboniferous limestones exhibit no characters corresponding to this description, and the palæontologists of our country who are disposed to adopt the name Archimedipora will do well to compare the generic characters given by M. D'Orbigny with the fossil itself.

For descriptions of several species of this genus see proceedings of the American Association for the Advancement of Science, Meeting of 1856.

ART. XXIV.—*On the Avoidance of the Violent Portions of Cyclones; with Notices of a Typhoon at the Bonin Islands;* by JOHN RODGERS, Commander, U. S. N., and ANTON SCHÖNBORN, Assist. Astronomer. Communicated by W. C. REDFIELD.*

(Read before the American Association at Albany, August, 1856.)

U. S. Ship Vincennes.

Dear Sir,—I am a firm believer, out of my own experience, in the truth of your theory of hurricanes. I think that you have enabled me to avoid storms, into whose centers I should have been unwilling to be involved, and I feel therefore that I am under personal obligations to you for your happy meteorological discoveries. You have conferred by them a great good to the nation and to the world.

I do not know whether my notes of weather have any value in regard to the hurricane experienced by the Mississippi on Oct. 7th, 1854. On Sept. 23d preceding this typhoon we were in the China Sea in lat. 21° 44′ N., lon. 119° 17′ East. The weather was very threatening. We were standing to the southward and a black cloud was ahead of us, with vivid lightning, with a cross and violent sea, with heavy rain, and fitful squalls continually increasing in frequency and force. I considered that I saw a cyclone before us, and that we should avoid its force, by sailing away from it. We stood to the northward. The barometer soon rose and the wind moderated.

At the Bonin Islands on October 28th, 1854, we had a typhoon. The harbor of Port Lloyd is formed by the crater of an extinct volcano. The sides rise precipitately above the water to the height of some twelve hundred feet. You will easily perceive then, that the anchorage must be in a great degree protected from the violence of the wind. Yet it blew awfully. It stripped all the leaves from the trees, all vegetation was blighted, and even the sweet potatoe vines in the sheltered valleys were destroyed by it. As I could not at first believe that the wind had destroyed them, I attributed their wilting and turning black to some unseen electrical agency. I afterwards concluded that the wind had twisted and torn their sap vessels, so as to destroy their vitality.

This storm was not so marked as to give any distinct warning of its approach. The evening before the hurricane the surf broke more heavily upon the mouth of the harbor than I had ever seen it. Had we been at sea I have little doubt but that we should have known of its approach. This storm is well de-

* This communication having been kindly placed at my disposal by Commander Rodgers, by way of answer to some earlier inquiries, I deem it improper to withhold it from publication.—W. C. R.

scribed in the accompanying paper by Mr. Schönborn, assistant astronomer on board.

We had a gale on Nov. 9th, 1854, in lat. 28° 22′ N., lon. 143° 45′ E., which I thought was the edge of a typhoon. We ran on until I had satisfied myself as to its character, and then we hove the ship to on the starboard tack heading away from it. We soon raised the barometer and improved the weather. This case is also described in the accompanying paper of Mr. Schönborn.

In the steamer John Hancock, which I commanded, we were on May 20th, 1854, upon the verge of a typhoon. The weather was not violent but the seas were peculiar, rising up into sharp cones and running in every direction. They buffeted the vessel in every part, striking her upon the lee bow and weather quarter at once. I remarked to the officers on board that I felt sure we were upon the edge of a typhoon. It gave me however no uneasiness. I concluded that we were behind it and that keeping the vessel away would increase our distance from it.

We steered off once, in a fresh squall, for about fifteen minutes, and hauled up to our course again. We ran on with a fair wind. I expressed a wish to know how any vessel some one or two hundred miles to the northward and eastward of us was faring. This curiosity was satisfied by the accompanying extract from the log-book of the British ship Harkura. She was a large Indiaman, well out of water, and in appearance such a strong wholesome vessel as a seamen would select to stand heavy weather.*

Typhoons are rare in the China seas in the month of May. This is therefore not without interest.

Very respectfully, your obedient servant,

JOHN RODGERS,
Commanding U. S. Surveying Expedition.

[*Extracted from Hong Kong Gazette of June 14th*, 1854.]

* The ship Harkura left Hong Kong for London May 16th, 1854, and returned to port under jury masts on the 11th of June. She had fine weather till the 18th, on which day boarded the Dutch bark Johan Paul, then just escaped from pirates. On the 19th, wind fresh and steady at E. and E.N.E. On the afternoon of 20th [nautical time] moderate winds from E.N.E., the barometer falling in the evening, with lightening at the southward. Latitude at noon of that day 16° 22′ N., lon. 113° E. At 10 P. M. a heavy bank rising in the S.E. with lightening and distant thunder; close reefed the topsails and stowed mainsail, spanker and jib. At midnight barometer still falling, took in mizzen topsail and foresail, and at 2 A. M. stowed main topsail. Not much wind, but sea getting cross and high. At 5 A. M. strong winds and heavy rain, barometer fallen three-tenths since the preceding noon. Sent down all top hamper and secured all sails with extra gaskets. At 10 A. M. [Sat. 20th] gale increased to a hurricane, with a fearful cross high sea. Stowed fore topsail and topmast-staysail and brought ship on to port tack, got a sail in mizzen rigging to keep ship to the wind, then so violent that no sail could stand it. At noon (commencement of 21st, nautical time), lat. by acc. 15° N., lon. 112° 20′ E.

The afternoon commenced with a severe gale speedily increasing to a perfect hurricane, barometer fallen down to 28·50. At 2 P. M. ship lying with her lee yard-arms

{ U. S. Ship Vincennes, Port Lloyd,
{ Bonin Islands, Oct. 27th, 1854.

During the past five days the weather had been rather warm, but very fine. Light winds from S. E. were prevailing, which kept the temperature of the air even in the night above 80°, yet in the warmest hours of the day it would seldom be over 85° in the shade. This morning before sunrise light squalls from S. E. accompanied by drizzling rain interrupted for the first time the

in the water, and bar. still falling rapidly. Fearing the ship would founder, cut away fore and mizzen topmasts; but that being insufficient to right the vessel, cut away the fore topmast. The vessel then righted a little, the wind still blowing with fearful violence and increasing. The main topmast now went over the side, taking with it the head of the mainmast. Immediately after this it fell a flat calm, the barometer down to 27·70. Got the wreck of main topmast cut away from along side, as well as that of the foremast which hung to windward. At 3 P. M. the wind flew to the N. W., veering to west and southwest, blowing with tenfold violence. The lee bulwarks all gone with everything moveable about the deck, the sea up to the combings of the main hatch. The starboard side of forecastle washed out and also starboard poop cabin. At 3.45 P. M. ship righting a little, rigged two pumps and pumped her dry. At 6 P. M. the fury of the typhoon moderated and barometer commenced rising. Gale continued at S. W., veering round to south. Commenced rigging jury masts. May 22d [nautical time] lat. 15° N., lon. 112° 10′ E. At 8 P. M. [21st, true time] weather moderated. Sea going down and barometer rising. Wind south and southeast.

Capt. Crowe's remarks on the above Typhoon.—The evening of Friday the 19th of May [civil time], the weather looked very threatening, but nothing gave reason for suspecting the vicinity of a typhoon. [!] The clouds had a dirty red appearance, but the quickly repeated flashes of lightening and the distant moaning of the thunder in the southeast quarter were portentous of an approaching gale. The barometer did not give early indication of what was coming, [!] only three-tenths of fall appearing up to the time of the commencement of the gale. The fall then however was very rapid, and in all of a twenty years experience (eleven in command) I never saw the mercury so low in the tube by an inch. During the lull, when we were in the vortex, the barometer, a standard one by Shepherd of London, stood at 27·50; afterwards, when we were engaged about the wreck of the masts, it was reported to me as standing at 27; in fact altogether out of sight. The wind commenced at E. N. E.; stood in that quarter 24 hours (moderate in early part), veered to N. E., whence it continued steady till we cut away the masts; then it suddenly subsided into a calm, which continued for half an hour; then, without a moment's warning, it opened out in nor'west in a most frightful tornado, so violent that words cannot express its force, and so continued for an hour, when it veered to west, and gradually afterwards to sou'west and south, with continued violence. Rain throughout very heavy. Had not the vessel been brought to on the port tack, as Horsburgh directs, when the wind shifted after the lull, the vessel must certainly have gone down stern foremost; as it was, the gust taking her over the stern, she came up to the wind and so lay in safety during the remainder of the cyclone.

[Note.—The interests of navigation require it to be stated, that on the evening before the disaster Capt. Crowe had, in the falling state of the barometer and the direction of the wind, sufficient evidence to show that *near by in the southeast was a typhoon, then crossing his path.* Had he wore ship at this time, or even brought to on the starboard tack, till the wind should have veered eastward and the barometer commenced rising, he would have sustained no damage. But in maintaining his course under the unchanging northeasterly wind and falling barometer, he pushed directly into the heart of the cyclone, as has too often been done by others.

Commander Rodgers was fortunate in falling behind the violent portion of this terrific cyclone, and was thus able to escape its force without changing his track. He appends the log-book records of the John Hancock, from which it appears that

continued fine weather we had experienced. At noon the wind changed to the north of east, the rain ceased, it began to clear up and I could see the blue sky at times between the slowly moving cumuli. In the afternoon about 3 P. M. being on shore, I heard some peals of far off thunder, seemingly to eastward; the same had been noticed on board ship. A range of mountains obstructed the sight to N. E., E., and S. E.; in the latter direction I perceived the high white tops of heavy clouds (cum.-str.) some distance off. Occasionally rain squalls passed on both sides of us. In the evening the squalls were more frequent, it rained often and profusely; the sky became overcast and hung round with dark looking clouds, especially to S. W., where we could see the horizon. At 8 P. M. barometer 29·859; sympesometer 29·896; aneroid 29·822; temperature of air 81°·1; of water 78°·7; of rain water 75°·2. About 8 P. M. flashes of vivid lightening to E. and N. E. and peals of heavy thunder occurred, which were repeated several times until 10 P. M. at intervals, stronger or fainter.

October 28th, 4 A. M.—During the night the squalls came from N. E. and increased much in violence. About 4 A. M. the wind hauled to eastward and began to blow more steadily. The rain fell all night and morning very abundantly and in large drops. bar. 29°·654; symp. 29·675; an. 29·639; temp. air 80°·6; water 77°·6; rain-water 75°·7. Towards 6 A. M. the wind hauled to S. E. by E., increasing; it lessened somewhat about 8 A. M. but regained soon its former strength from E. by S. Rain now fell incessantly, but in smaller quantity. Temp. of rain-water 77°. The weather had a very dark and threatening appearance, a thick mist covered the horizon seawards, the surf broke high and violently on the reef near the entrance of the harbor and on the rocks outside.

At 9 A. M. bar. 29·471; symp. 29·465; an. 29·450; temp. air 81°·1; water 77°·7; rain-water 77°; wind S. E. by E., force 7. After 10 A. M. the wind increased continually, shifting by degrees to S. E.; the barometers and sympiesometers fell rapidly. A waterspout was observed at 11 A. M. in the mouth of the harbor moving quickly southwestward. It had nearly the height of the neighboring south bluff, behind which it disappeared. By going over the breakers, a great quantity of spray was carried away with it, whirling around the cylinder. The clouds were not de-

before 3 P. M. of May 20th the barometer fell to 29·60; in which time the wind veered by the N. W., to W. by N., its greatest force, 6; the course of the vessel about N. N. E. Lat. at noon 11° 55′ N., lon. 111° 17′ E. This corresponds to the Harkura's *nautical* date of 21st; her distance from the John Hancock then being 195 miles; the Hancock being then about 180 miles from the vortex. From 3 to 6 P. M. the barometer rose but little. Later in that day the wind was W. by S., and then variable, the bar. rising to 29·80. The 21st commenced with wind at S. S. E., which continued so till noon, in lat. 13° 51′, lon. 112° 47′. Course N. by E. After meridian the wind varied from S. S. E. to E., diminishing in force to 3.—W. C. R.]

fined except the scud, which flew swiftly at no great distance above us. Shortly before noon the weather became thicker, the surrounding hills appeared as indistinct shadows, indeed we were sometimes so entirely enveloped in mist and fog, that we could not see a ship's length around us.

Noon, bar. 29·123; symp. 28·956; an. 29·100;* temp. air 79°·8; water 77°·7; rain-water 75°·7; wind S. E. ½ E., 10. At 1·45 P. M. the wind had attained its greatest force aud blew with unabated fury until 3·30 P. M., veering in this time from S. E. by S. gradually to S. W. ½ W. There was no calm at the climax of the storm noticeable. The sympiesometer stood lowest at 2·20 P. M. (at 28·233, wind S. by W.) and the barometer and aneroid at 2·30 P. M. (at 28·443 and 28·482, wind S. ½ W.)† All three instruments remained but a few minutes at their lowest position and rose then as rapidly as they had fallen. It rained almost continually, rather lightly, but the drops fell with great violence and made me at first believe them to be mixed with hailstones, which idea however I found contradicted by examination and by the temperature of the rain-water. As the wind turned to the westward of south, there came a heavy swell through the entrance of the harbor, which increased as the wind hauled more to the west. After 3·30 P. M. the force of the wind diminished slightly.

At 5 P. M., bar. 29·169; symp. 29·060; an. 29·178; temp. air 77°·7; water 77°·7; wind W. by S. ¼ S., 10. Towards sunset the weather moderated, the clouds assumed shapes again and for a short time had a remarkably lurid appearance, the whole atmosphere, filled with vapor, seemed to be lighted up and gave to the surrounding landscape a yellowish tinge.

At 8 P. M. bar. 29·533; symp. 29·459; an. 29·529; temp. air 77°·6; water 77°·7; wind S. W. by W., 8. Fresh squalls of light rain from S. W. by S. and W. S. W. passed frequently. The form of the clouds looked loose and jagged. Now and then the sky was partially clear overhead and the stars were visible even through the thinner mist-like clouds.

* [Mr. Schönborn appends an excellent diagram showing the fall and rise of the barometer under the successive winds of this cyclone as it passed over the ship, as determined by frequent and careful observations. He adds also the curves indicating the movements of the sympiesometer and aneroid during the same period. It is a graphic exhibition of the effective action of the cyclone, and affords a fair test of the relative value of these several instruments, under the successive phases of the storm. He adds two other diagrams of like character; one of which, together with that just noticed, I have reduced for these pages, so far as relates to the barometer. I regret that they could not be reproduced entire, on this occasion.—W. C. R.]

† [The nearest approach of the axis or center was indicated by these lowest observations. As the gradual veering of the wind was in accordance with the apparent daily course of the sun, and no lull or remission having occurred at the crisis of the gale, it is evident that these observers were to the right of the axis-path, which swept around to the southward and westward of Port Lloyd. Thus at the time the barometer was lowest here, the cyclone had partially completed its recurvation and was entering upon its northeasterly course of progression.—W. C. R.]

October 29th, 4 A. M., bar. 29·748; symp. 29·652; an. 29·744 temp. air 78°; water 78°; wind W. S. W., 5. The weather has been improving much during the night.—9 A. M., bar. 29·853; symp. 29·830; an. 29·850; temp. air 80°·8; wind light from the westward; weather very fine. Very respectfully,

ANTON SCHÖNBORN,
Assistant Astronomer.

U. S. Ship Vincennes, November 9th, 1854.

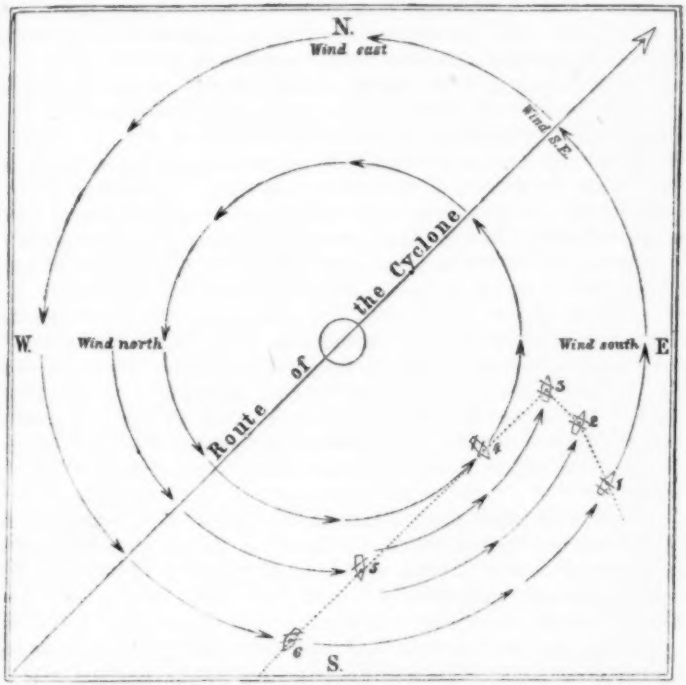
During the day we had pleasant weather. A steady south wind blew all the morning, advancing us speedily on our way to the north. In the afternoon the wind freshened, hauling to S. S. W. The barometer and sympiesometer had been falling since 8 P. M. of the previous day, and stood at 3 P. M. at 29·717 and 29·710; temp. air 81°·1; water 78°·4; wind S. S. W., 7. We were then in lat. 28° 43′ N., lon. 143° 59′ E.

Towards evening when the sun neared the horizon, he glared with unusual brightness through the clouds, and the sunset was magnificent. The gilded edges of the cumuli to N. W. contrasted finely with the dark appearance of the cloud-bank which began to rise on the horizon. South and westward the upper and lower strata of clouds exhibited a great variety of colors from pale yellow to brilliant purple, and some of them, which passed swiftly overhead, were even of a greenish hue. A low compressed mist, orange colored, lay on the water to the west, serving as a line of demarkation between the calm and beautifully decorated sky above and the already troubled sea below.

As the glow of the sunset lessened, the cloud-bank to N. W. and W. N. W. began to rise, and when it became dark, flashes of vivid lightening followed each other in rapid succession, illuminating at times the whole northwestern part of the heavens. The wind veered back to S. by W. increasing considerable in force, accompanied by sudden puffs. The waves became high and irregular, owing to a cross swell from S. and N. W. A thick mist enveloped us sometimes so that only a small space overhead was clear. The barometer fell constantly. At 8 P. M. *the ship was hauled by the wind on the starboard tack, with the head to the eastward.* The barometer and sympiesometer stood lowest at 9·20 P. M. (29·548; 29·572). At this time also the wind was most vehement from S. S. W. The barometer began to rise after half past 9 o'clock. Towards midnight the weather moderated slightly. The wind blew in gusts from S. W. veering by degrees to westward and some showers of rain fell. At 4 A. M. on the 10th the force of the wind had greatly diminished, hauling to W. N. W., and the weather cleared up.

It is very probable that we were in the southeastern wing of a cyclone. From the collected facts the following diagram has

been constructed. By the general appearance of the sky and the swell, which came at first from N. W. and afterwards from N. it seemed, that the storm moved to N. E. We ran at first into it, and by lying to the storm left us, passing on its way to N. E. We entered the circle at No. 1 with a course of N. N. E., which was soon after changed to N. by E.; our position on the diagram therefore became successively that of No. 2 and No. 3.



Position No. 1.—Nov. 9th, 2 P. M. Wind S. S. W.; ship's course N. N. E., which was changed at 4 P. M. to N. by E.

No. 2.—6.30 P. M.; wind S. S. W.; ship's course N. by E.; cloud-bank to N. W. (towards the center of the storm.)

No. 3.—8.20 P. M.; wind S. by W.; ship's course N. by E.; after which the ship was hove to, head eastward.

No. 4.—9.20 P. M.; wind S. S. W.; lowest barometer, strongest wind. (Nearest the center.)

No. 5.—Nov. 10th., 1 A. M.; wind westward. Weather moderating.

No. 6.—3 A. M.; wind W. N. W.

Very respectfully,

ANTON SCHÖNBORN,

Assistant Astronomer

ART. XXV.—*On the Mode of Formation of Cannel Coal;* by J. S. NEWBERRY.

(Read at the Albany meeting, Amer. Association, Aug. 1856.)

CANNEL coals as a class, when compared with other bituminous coals, are characterized by greater homogeneity of physical structure and of chemical composition, have a more laminated fracture,—in pure specimens conchoidal across the planes of stratification,—contain more earthy and more volatile matter,—and of course less fixed carbon,—and evolve gases having a higher illuminating power. The fossils which they contain are either aquatic or exhibit marks of the action of water. No satisfactory explanation of these differences having been given by writers on the subject, I was led to seek such explanation in the phenomena presented by the numerous strata of cannel coal which are found in the Ohio portion of the Alleghany coal-field.

A series of observations on these beds of cannel, on the changes which they exhibit in going from one point of outcrop to another, their physical and chemical characters, their structure as indicative of their mode of deposition, their fossils and geological associations, has resulted in giving me the conviction that the peculiarities of cannel coals are due, principally, *to the chemical and mechanical influence of water in which they were deposited*, secondarily and locally, *to the presence of a portion of animal matter.*

The facts which have led me to these conclusions are briefly these:—

1st. Cannel coals always exhibit a tendency to assume the foliated structure of slates and shales,—a structure which they must have derived from aqueous deposition. They are frequently found shading into bituminous shale, into which they are converted, simply by accessions of earthy matter. Bituminous shale and cannel coal may, therefore, be considered as the same substance in different degrees of purity; that is, carbonaceous paste, deposited from aqueous suspension with different admixtures of earthy matter.

The carbonaceous matter in bituminous shale, as in cannel, exhibits a preponderance of volatile matter over fixed carbon, and the gases furnished by it contain a larger proportion of the more volatile hydro-carbons, and possess a higher illuminating power than those derived from ordinary bituminous coal.

2nd. The chemical composition of cannel coal—so rich in volatile ingredients—and its homogeneity, are such as would naturally follow the decomposition of vegetable matter while constantly submerged.

Plants when deprived of their vegetative life, and exposed to the action of the air, are slowly decomposed by the process of

decay; a process, which, unattended by the sensible phenomena, heat and light, is however really a combustion and consists in the union of oxygen with their hydrogen to form water, with their carbon to form carbonic acid, and of their carbon and hydrogen to form carburetted hydrogen, &c.

When vegetable matter is covered with wet earth or clay, these changes are both modified and retarded, and an intermediate state, that of bituminization, is assumed by a portion of the organic matter.

Under water the changes terminating in decay go on still more slowly, and a larger portion of the vegetable tissue becomes bituminized.

The process of bituminization in such circumstances consists in the oxydation of a small portion of carbon—which escapes as carbonic acid,—of hydrogen to form water, the union of carbon and hydrogen to form carburetted hydrogen and other hydrocarbons, and the combination and removal of a portion of the alkaline carbonates, of nitrogen, &c., all of which go to make up the loss, which is relatively small. The residuary hydrogen and oxygen unite with a portion of the carbon to form bitumen, which closely resembles, physically and chemically, the resins produced by the vital functions of many plants. This bitumen unites mechanically with the uncombined or fixed carbon, the remaining alkalies and inorganic matter, to form coal.

It is evident that the more ready the access of oxygen to the carbonaceous matter during the process of bituminization, the larger proportion of the products of complete combustion will be mingled with those of this process, and the more perfectly the oxygen is excluded, the larger proportion of the more volatile (i. e. more oxydable) constituents of the wood will be retained.

Of the conservative influence of water on vegetable matter we have evidence, not only in the great durability of wood when constantly submerged, but in coal itself.

In all coal strata except where the process of volatilization is complete, as plumbago and perfectly gasless anthracites, the work of decomposition is constantly going on. To this, as to ordinary combustion, water is an extinguisher.

Coal mines are commonly opened in this country by penetrating the coal on some hill-side where it is not covered by water. In these circumstances a progressive change, both chemical and physical, is noticeable in the coal from its outcrop to the point where atmospheric influences cease to act. Near the surface it is friable, lustreless, and nearly destitute of gas, having much the appearance and character of decayed wood. As it is more deeply penetrated it becomes harder and more brilliant, and contains more volatile matter, till under water or a sufficient cover of incumbent rock, it is protected from the action of oxygen.

On the contrary, whenever the outcrop of a coal stratum is constantly covered with water, even though it have no other covering it will be found hard and bright, and containing nearly its maximum quantity of volatile ingredients.

3rd. The higher illuminating power of the gases of cannel is a natural consequence of the preservation of the more volatile constituents of wood, by its continued submersion in a hydrogenous liquid.

It is also probable that the illuminating power of cannel gas is often somewhat increased by the animal matter which it contains. I have found remains of fishes in slaty cannel, surrounded by bitumen having in a high degree the characteristics of the bitumen of cannel.

That a more resinous vegetation has given cannel this character is, I think, not probable. I have often found unchanged resins in common bituminous coal, but never in cannel.

4th. The greater relative proportion of earthy matter in cannels would be a necessary result of the submersion of the vegetable matter in a fluid having a greater specific gravity than air, and, of course, greater power for the suspension and transportation of sediment. In the few instances known where the cannel is of equal purity with bituminous coal, we may I think discover evidences that the vegetable matter has been deposited in confined bodies of quiet water, entirely without currents, or, at least, receiving little or no surface drainage.

5th. The fossils contained in cannel coal are among the most significant indications of its aquatic origin.

Fishes are found in cannel in abundance, scales, teeth, spines, coprolites, and entire individuals being, in some localities, so profusely scattered through its substance as to prove conclusively that they must have lived and died in great numbers in waters, at the bottom of which comminuted vegetable matter was accumulating as a carbonaceous paste, with which their remains have mingled, and the whole, consolidated, has become a stratum of cannel.

I have before me as I write, pieces of beautiful cannel from England, in which are impacted teeth of *Megalichthys*, scales of *Paleoniscus*, and many other forms of aquatic life. And in Ohio I have found fishes in large numbers in a thin stratum of cannel underlying a thick seam of bituminous coal; which last contains none.

Shells too are not unfrequently found imbedded in the middle of a stratum of cannel.

The vegetable remains which I have observed in cannel are *Stigmariae*,—roots and rootlets of trees which grew in the coal-marshes,—generally occurring in detached fragments—shapeless portions of the trunks of *Lepidodendra* with their markings

nearly obliterated, *Lepidostrobi* reduced to their woody skeletons, fern fronds of which nothing but rachis and veins remain, all evidently macerated till only their most resistant tissues are left.

Strata of ordinary bituminous coal usually consist of thin layers of brilliant bitumen alternating with others of bituminous shale or cannel. This arrangement I consider due to the variable quantity of water saturating and overflowing the coal marshes: the cannel layers having been deposited during the prevalence of high water.

ART. XXVI.—*Abstract of a Meteorological Journal kept at Marietta, Ohio, for the year* 1856—Lat. 39°·25 N., Long. 4°·28 W.; by S. P. HILDRETH.

MONTHS.	THERMOMETER.						Winds.	BAROMETER.		
	Mean temperature.	Maximum.	Minimum.	Fair days.	Cloudy days.	Inches of rain and melted snow.		Maximum.	Minimum.	Range.
January,	17·87	45	−13	15	16	2·75	W. N. W. & S. W.	29·90	28·90	1·00
February,	25·50	50	−15	14	15	1·66	W., N. & S. W.	29·70	28·60	1·10
March,	32·13	57	−10	16	15	1·34	W. N. W. & N.	29·70	28·75	·95
April,	54·33	85	19	23	7	2·25	W., S. S. W. & E.	29·70	29·00	·70
May,	61·20	90	38	16	15	4·16	N., S. & S. W.	29·60	29·03	·57
June,	72·44	95	46	22	8	5·25	W., S. E. & S.	29·55	29·20	·35
July,	75·53	100	52	30	1	2·50	S. W. & S.	29·65	29·12	·53
August,	73·43	93	46	21	10	2·75	W., N. W. & S. W.	29·55	29·00	·55
September,	64·77	95	35	20	10	1·17	S., S. W. & S.	29·60	29·10	·50
October,	53·76	87	28	18	13	2·42	S., S. W., & E. S. E.	29·75	29·20	·55
November,	41·41	70	16	17	13	4·00	S. W., W., & E.	29·70	28·65	1·05
December,	29·23	54	0	16	15	2·21	N., N. W., & S. W.	29·80	28·96	·92
Mean,	50·13			228	138	32·46				

THE year which has just closed has been marked by some peculiarities, different from common years; the most prominent of which, were the excessive cold of the winter, and extreme heat of the summer—also the drouth of the spring months and hottest portion of the season; the failure of some of the crops, and unusual exemption from disease, in all portions of the valley of the Ohio.

Remarks on the seasons.—*Winter.*—The cold in January was longer continued than in any preceding year, reducing the mean temperature of the month to 17°·87, the lowest mean temperature of any winter month in the last forty years, the minimum being a little below 21°. On several mornings the mercury was at twelve and thirteen degrees below zero, and on seven mornings at and below that point. The extreme of cold was not so great as in January, 1852, when it was −23°, on one morning only

and the mean for the month was 24°·36; on the 9th and 11th of this month in 1856, at 4 o'clock, A. M. the temperature was −21°, as observed by a gentleman who lives four miles above Marietta, near the Muskingum river. Eighteen miles above, it stood at −25°, as observed by Dr. Bowen of Waterford, at the same hour—my period for observing being 6 o'clock or about sunrise. The greatest degree of cold noted by myself during the winter was in February, when it was at −15° the fifth day of the month. This season was also one to be remembered, for the great amount of snow, there falling during this period four feet and six inches at thirty-two different times. The greatest quantity at a single fall was thirteen inches, but by additions accumulated to about twenty-four inches, especially in the forests. Twenty-five miles north of Marietta it was several inches deeper, and near Pittsburgh was said to be three feet. By the aid of light rains and occasional slight thaws, the snow became consolidated, and nearly as heavy as ice. It did not melt much until early in March, and in the forests and on the north hill sides, was from twelve to eighteen inches deep until after the 20th of the month. The ice in the Ohio and Muskingum rivers was from twelve to twenty inches thick, having been constantly increasing since the first of January, when the rivers were frozen over. Boats ceased to run on the 30th of December, and did not resume navigation till the 3d or 4th of March, when the ice gradually gave way without much of a rise in the head waters, beginning from below and working gradually up stream, contrary to the usual course, without much damage to boats. From the unusual quantity of snow, it was expected a great flood, like that of 1832, would attend the breaking up of the rivers, but the snow was so much consolidated that it melted very slowly and thus happily disappointed the fears of the inhabitants along the borders of the rivers. The mean temperature of the winter months of 1855–56, was 25°·67, which is the lowest on record—that of 1846 being 29°·91—but usually our winters range from 32° to 36°.

Spring months.—The mean temperature for spring is 49°·22, which is more than two degrees below that of the year 1855, and four below that of 1854, which is mainly attributable to the low grade of the month of March, being in 1854, 47°·55; and in 1856, 32°·13; a difference of more than fifteen degrees, occasioned by the great amount of snow on the ground until near the close of the month. The blossoming of fruit trees was much retarded; the peach, where the fruit buds escaped the deadly effects of the winter, not opening until the 22d of April, and the pear and cherry on the 29th, twenty days later than the ordinary period. The season was uncommonly backward—much trouble was experienced by our farmers in the germination of seeds, especially of Indian corn, in many fields requiring two or three plantings;

the grain rotting in the ground, probably the effect of the last winter's cold acting on the vitality of the imperfectly ripened grain. Frosts as late as the middle of the month also retarded its growth, so that until the first of June the prospect of a poor crop of corn was very apparent; the dry weather which set in with the heat, completed these fears, and the result was a very light yield of this important bread stuff. The amount of rain for the spring months is $7\frac{7}{100}$ inches. In 1854 it was nearly twelve inches.

Summer months.—The mean of the summer temperature was 73°·80, which is somewhat higher than in 1854, the latter being 73° 55, the extreme heat in 1856 being greater than in 1854 by two degrees, rising on the 17th of July to 100°, while the highest in the hot summer of that year was 98°. The nights were cooler than in 1854, generally of a temperature not uncomfortable to the sleeper. The quantity of rain during the summer was $10\frac{50}{100}$ inches. In 1854 it was $9\frac{36}{100}$ inches, a difference of a little more than an inch. Nevertheless the smaller amount in the spring, nearly five inches, caused earlier and greater suffering of the crops, than in 1854, especially in corn, hay and potatoes, which were very light. The good results of deep and thorough tillage were fully seen this year, as in the former one—the mellow condition of the soil to the depth of ten or twelve inches affording a satisfactory return, when four or five inches was a complete failure. Should these dry seasons continue to recur as a permanent condition of our climate, the only remedy will be irrigation or very deep plowing. From the broken and hilly condition of southern Ohio, it is probable that irrigation can but partially remedy the evil, while deep tillage is within the control of every cultivator. The crop of wheat was good, as its growth was chiefly attained in the cooler and more moist season of the year. The yield of apples was light, and those much injured by the Curculio and other insects. Peaches, an entire failure, being killed in the bud by the winter; grapes, quite light, many vines being entirely, or partially killed. The fruit was of excellent quality, full of sacharine juice, perfected by the great heat of the summer. Sweet potatoes, now an important portion of good living, were greatly lessened in amount by the drouth, but were of good size and perfect in all respects as an article of food. Melons were abundant and in perfection, the hot and dry weather agreeing better with their nature and habit, than any other production. Many of the pear buds were killed by the cold of winter, and crop light, but of good quality. In Iowa and northern portions of Illinois, all the pear trees and a great many apple trees were seriously injured or killed. Peach trees fared still worse, being of a more delicate nature. Plum trees and cherry trees were nearly all destroyed, indicating a gloomy future to the fruit grower, as what has once happened may again be expected.

The mean temperature of autumn was 53°·31, over three degrees less than in 1854, and in 1855. The early frosts in September, did considerable harm to the unripened corn, as it was nearly a month later than usual from the necessity of repeated plantings; from the combined effects of drouth and frost, the crop of corn was unusually light and poor in quality. The price ordinarily twenty-five cents was increased to fifty or sixty cents. Potatoes were much lessened in amount, but fine in quality, selling from one dollar, to a dollar and a quarter a bushel. The amount of rain in autumn was $7\frac{5\,0}{1\,0\,0}$ inches, against 13 inches in 1855, and 9 inches in 1854. From the low stage of water, it was the 5th of December before the smaller class of steamboats could run on the Ohio, a fall of rain on the 28th November of $2\frac{8\,0}{1\,0\,0}$ inches, caused a rise of three or four feet and finally to six feet, enabling the flat boats to take off the productions of agriculture, coal, salt, and the great amount of manufactured articles which had accumulated in the last few months. The Ohio was clear of ice until the middle of December, and closed on the 18th, it was frozen over at several points by the 23d, the temperature on this morning falling to zero. On the 22nd, snow fell to the depth of two inches, with light showers on the following days. The ice, in still water, by the 25th had thickened to six or seven inches, and the dealers in that article were filling their houses for summer use.

The mean temperature of the year is 50°·13, which is lower than known before since 1836; then it was 50°·02. The amount of rain and melted snow is $32\frac{4\,6}{1\,0\,0}$ inches, being ten inches below the mean average for this place, and one below any former year—1839 being $33\frac{3\,2}{1\,0\,0}$ inches.

Injurious effects of the winter on plants.—The blossom buds of the Magnolia conspicua and purpurea were killed, as well as much of the wood of the latter. Pyrus Japonica, nearly all the buds but not so much of the wood as in 1852. Forsythia viridissima, the flower buds but not the wood. Weigelia rosea, and Spirea Prunifolia, from the same region of China, were uninjured, thus establishing their hardihood, and adaptation to this climate. The tree peony, although protected as usual with matting, was much damaged, nearly every bud being killed and much of the wood to the ground. Chinese Lonicera or evergreen honeysuckle, killed to the roots. Tree box, in exposed positions killed, much of the tops, and the dwarf box mostly destroyed root and branch, even where covered with snow. English yew tree, killed much of the foliage and some of the branches. Paulonia imperialis, greatly damaged, and large branches entirely killed; the Catalpa, although of the same family not injured. The American Holly of the Southern States much injured. Chinese Aborvitæ, damaged. Peach buds destroyed; and many old

trees killed. A portion of the apple trees injured, killing the bark in the forks of the branches, so long in contact with the frozen snow. It was the hardest winter ever known in Ohio.

Floral Calendar.—March 6th, Robin heard singing this morning; 29th, Yellow Crocus in bloom, later than usual.—April 2nd, Blackbird appears, White Crocus in bloom; 3d, Crown Imperial, 6 inches high; 9th, Hepatica triloba opening its petals; 12th, Early Hyacinth; 15th, Hepatica in full bloom; 16th, Sanguinaria Canadensis; 17th, Forsythia viridissima, near the ground where protected by the snow; 18th, Crown Imperial; 19th, Daffodill, Pyrus Japonica, a few blooms, mostly killed by the winter; 23d, Peach in blossom, where protected by buildings, generally killed; 26th, Cherry and Spirea Prunifolia; 28th, Pear tree, such buds as escaped; 26th, Red Cherry. May 1st, Apple tree in bloom, Circis Canadensis or red bud; 2nd, Papau, Tulip opening; 5th, Tulip in full bloom; 8th, Horse-chesnut, European species; 10th, Quince tree; 11th, Apple tree shedding its blossoms; 12th, Ranunculus, single flowered tree peony, more hardy than the double yellow mocasin, or Calceolaria; 15th, Lily of the valley; 16th, Haw tree; 18th, white mocasin; 19th, Locust tree; 20th, Magnolia tripetala; 22nd, Purple peony; 23d, Weigelia rosea and Blackberry; 25th, white herbaceous peony; 28th, fragrant Syringa; 29th, fragrant peony; 30th, frost this morning, killing melon plants, &c. June 2nd, Peonia Whitleji; 3d, Strawberry ripe; 5th, Kalmia latifolia; 6th, Syringa Philad.; 20th, Pomegranite, Red cherry ripe; 24th, Catalpa in bloom; 28th, Red Raspberry ripe.

Uncommon Insects.—Early in the month of May there appeared on the white oak trees on the hills near Marietta, and in the neighboring towns, vast numbers of worms; when fully grown they were about an inch and a quarter in length, and an eighth of an inch in thickness, cuticle smooth, color of india ink, tinged with blue, two black lines extended the length of the back; the sides marked with pale green, lozenge-shaped figures, head black; fourteen feet, six on a side, the two anal ones standing out like the tail of a swallow. They were exceedingly active in their movements, and great devourers, destroying all the leaves on a large white oak tree in a few days, so effectually that many of the extreme branches perished in the course of the summer. They were so numerous on young trees, as in one instance to bend the top, six feet high, to the ground. They had completed their course by the 10th or 15th of June, when they were inclined to come down to the earth, they descended by the aid of a silken thread, spun for that purpose. They made no webs or nests like ordinary caterpillars. In many respects they resemble the canker-worm of New England, "Phalæna vernata." Their favorite tree was the white oak, but where adjacent to the forests,

they visited and devoured the leaves of the apple tree, and also the young shoots of Indian corn. Before apple trees were planted in America, it is probable the oak and elm were their natural food. This worm has not been noticed before here, at least in such multitudes; it was new to all our old farmers, and should it prove to be the real canker-worm it will be a serious pest and evil to the orchards in this part of Ohio. I had a number collected when full grown and tried to feed and make them hybernate in a flower pot filled with moist earth, but they all perished before entering the ground. Had this succeeded, a more perfect history of the insect could be given, with drawings of both the male and female moth. All I accomplished was the preservation of several of the larves in alcohol.

ART. XXVII.—*On some Soluble Basic Salts of Tin;* by JOHN M. ORDWAY of the Roxbury Laboratory, Mass.

SOME years ago a singular liquid came to my notice, in the course of my business, under the strange sounding but appropriate name of nitrate of tin; and while seeking to determine its nature, some things were observed that are unexplained in systematic treatises on chemistry. But some properties since shown to belong to the salts of alumina have been found, by further experiments, to be possessed also by certain combinations of tin.

It is well known that when we attempt to dissolve tin directly in pure nitric acid, the metal is simply changed to insoluble stannic acid, nitric oxyd being given off. To be sure, if feathered tin is put into very weak nitric acid, say of specific gravity 1·15, a small quantity is quietly taken up, but in a short time it is thrown down again as a white powder containing no nitric acid. If however a very little chlorhydrate of ammonia is first added to the dilute acid, the reaction is different; nitrous oxyd is given off and the metal remains permanently in solution. A small proportion of chlorhydric acid answers the same purpose as the ammonia salt, since the first portions of tin added, deoxydize a portion of nitric acid and ammonia is formed, according to a well known reaction. Indeed as circumstances vary, we may have the formation of ammonia, the evolution of nitrous oxyd, or the disengagement of nitric oxyd; and often all three phenomena occur in the same experiment.*

* The same, as is well known, is partially true of some other metals. Thus I have observed in making nitrate of lead in the large way, that nitric acid of sp. gr. 1·14 dissolves lead rapidly, giving off protoxyd of nitrogen almost pure, while a stronger acid acts more slowly and nitric oxyd is evolved.

It is not easy to determine whether the presence of ammonia is essential to prevent the formation of stannic acid, for we cannot keep it out. We might infer that nitrate of ammonia would answer instead of the muriate, but such I have not found to be the case. It seems more probable that the chlorhydric acid is what exerts the needed influence.

The nitrate of tin before mentioned, was made by dissolving one equivalent of sal-ammoniac in nine of nitric acid of specific gravity 1·16 and dropping in gradually six equivalents of tin. It can be made right only in cool weather. It is a brown liquid which behaves with most reagents like the proto-salts of tin, and but for its color we might take it to be merely a protonitrate. But by operating with a stronger nitric acid mixed with a large proportion of muriatic acid, we may push the matter a great deal farther and get entirely beyond the reach of such a supposition.

In repeating former trials, experiments have recently been made with nitric acid of specific gravity 1·39, and muriatic acid of specific gravity 1·16, mixed in various proportions. In one case equal parts of each acid took up tin enough to make a liquid of specific gravity 2·24, having about the color and consistence of molasses. Analysis showed this solution to contain about 24 equivalents of tin to 3 equivalents of nitric acid, 6 equivalents of chlorhydric acid, and 2 equivalents of chlorhydrate of ammonia.

Here we have eight equivalents of tin retained in solution by three of acid.

Another sample made with four parts of nitric acid to three of muriatic acid, had the specific gravity 2·443 and had four equivalents of tin to one of acid.

These highly basic combinations keep well except in the hottest summer weather. They unite with water in all proportions without change. Weak acids produce no alteration of the color. The alkaline carbonates in excess, precipitate a yellow oxyd of tin, leaving the liquid colorless. Such nitromuriates show no tendency to crystallize, but by spontaneous evaporation dry down to a tough, shiny, translucent mass, which readily dissolves again in water. In fact they very much resemble the basic nitrates of iron mentioned in a former volume of this Journal.* And in making the tin solutions, as in adding iron to nitric acid, the reddish color begins to appear when the compounds begin to become basic. Reagents show that the tin exists in neither the highest nor the lowest degree of oxydation. The protochlorid of tin cannot be made in the slightest degree basic without precipitation; and the same seems to be true of all

* Vol. ix, [2], p. 30.

protosalts. To be sure, strong chlorid of zinc, as we often see in making large quantities, on being tested with metallic zinc, oxydizes and dissolves an excess of the metal, and the solution remains perfect after cooling, but dilution causes an immediate precipitation of oxychlorid. The basic nitrates and acetates of lead are, on the other hand, but slightly soluble in cold water. While the basic sesquisalts are uncrystallizable and miscible with water in all proportions.

It was therefore natural to suppose that in the tin salts in question, the tin must be in the form of sesquioxyd; and farther that the production of such combinations would settle a hitherto mooted point, by showing that there is a salifiable sesquioxyd of tin as truly as a sesquioxyd of iron.

And now to determine whether any fallacious appearances could originate from the nitric acid or the ammonia present, another mode of formation was resorted to. Twelve equivalents of protochlorid of tin,—the "tin crystals" of commerce,—were dissolved in their own weight of warm water, and one equivalent of crystallized chlorate of potash was added by degrees, as fast as the violent reaction would allow. The result was a clear, high-colored liquid containing of course no foreign matter except a very little chlorid of potassium. By adding a solution of nitrate of lead, a red nitrate of tin was formed. Carbonate of lead added to such a nitrate or to the muriate, removed nearly half the acid without any precipitation of tin.

In this way then permanent solutions may be made containing about three equivalents of tin for two of acid, but for some reason they cannot be made more basic without gelatinizing; perhaps because of the great degree of dilution necessary to enable the neutralization of the acid to go on, for it appeared in the direct way of making, that a mixture of weaker acids, would dissolve much less tin.

But the chlorate of potash process proved too much, since it was found that when one equivalent of the chlorate acted on six equivalents of the protochlorid, the tin was completely oxydized making a clear and almost colorless liquid. So the permuriate of tin may be basic and yet soluble. And it further appeared on adding carbonate of baryta or carbonate of lead, that two thirds of the acid might be abstracted without gelatinization. Three equivalents of bibasic permuriate would bear the addition of two equivalents of alkali, and if three equivalents of protochlorid of tin were also present it would bear no more, and therefore the basic sesquinitrate might be looked upon as a mixture of protonitrate and basic pernitrate.

Various other experiments have established the hitherto unnoticed fact that *the soluble salts of binoxyd of tin may be made*

highly basic and yet remain soluble,* a fact of some practical importance, and one which seems likely, in connection with others already observed, to lead to the more comprehensive generalization that the soluble salts of the peroxyds, remain soluble when the larger part of the acid is abstracted.

As for the existence of true salts of the sesquioxyd of tin, there appears to be as yet no other evidence but such as may be drawn from color. The fact that the sesquioxyd dissolves in ammonia, while the protoxyd does not, of itself proves nothing, for why might not stannic acid render protoxyd of tin soluble in ammonia, just as arsenic acid does the sesquioxyd of iron? But the hydrated protoxyd and peroxyd of tin and their ordinary salts, as well as the stannates, are colorless, while intermediate substances may be formed that are colored. This becomes strikingly apparent if we make a basic permuriate of tin by oxydizing neutral protochlorid of tin with chlorate of potash or nitric acid, and then drop into the colorless or slightly yellow solution a few crystals of protochlorid of tin which will presently strike a red color. This red solution gives a reddish precipitate with alkaline carbonates, thus showing that Fuchs's sesquioxyd of tin may not be colored by iron, as is generally supposed. A mixture of two colorless oxyds, could not be yellow, and it would be strange if a stannate of a white protoxyd were not white. Frémy's metastannate of protoxyd of tin, made by digesting metastannic acid in neutral protochlorid, is indeed yellow; but is it certain that SnO, Sn_5O_{10} represents the true composition? At any rate, I find that this product, gives with weak chlorhydric acid a greenish brown solution which darkens somewhat on exposure to sunlight,—a singular action for a true salt composed of colorless constituents.

A brown hue is sometimes developed on dissolving in hot water the residue obtained by boiling tin in strong sulphuric acid. Again crystallized protochlorid of tin when kept for a long time in loosely stoppered bottles, is apt to turn yellow, especially on the side next the light.

Color appears to arise then during the deoxydation of peroxyd or of basic persalts, or the oxydation of the protosalts. So unless it can be shown that the olive and the red forms of the protoxyd may enter into combination retaining their respective colors, we seem forced to admit the existence of one or more intermediate oxyds of tin.

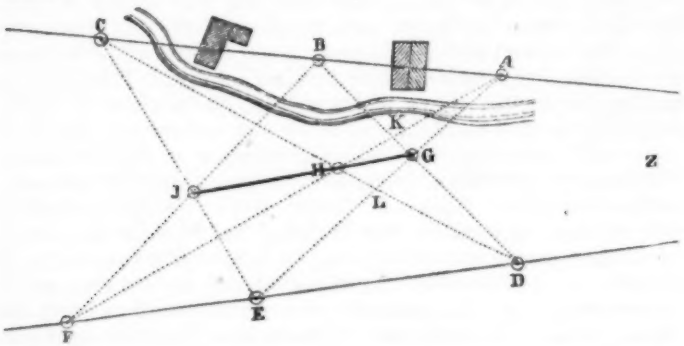
Roxbury, Mass., January 10th, 1857.

* Gmelin misled by theoretical reasoning, says, "If a normal stannous salt is to be converted into a normal stannic salt by the action of air or nitric acid, it must first be mixed with a quantity of acid equal to that which it already contains; in default of the requisite quantity of acid, a precipitate is formed during the oxydation, consisting either of the hydrated stannic oxyd or a basic salt."—*Handbook*, Cav. Soc's. Ed., v., p. 75.

Now as far as oxydation by nitric acid is concerned, this statement has been found at variance with actual results.

ART. XXVIII.—*A Problem in Practical Surveying: demonstrated by means of Transversals;* by W. M. GILLESPIE, Prof. of Civil Engineering in Union College.

LET A and B represent two points, inaccessible, and invisible from one another. Let it be required to find a third point, C, in the line of A and B, but invisible from them. It is supposed that no means of measuring either distances or angles are at hand.



The problem may be solved thus. Set three stakes, D, E, F, in a straight line. Set a stake, G, in the line of DB and EA; set a stake, H, in the line of FA; and a stake, J, in the line of FB, and at the same time in the line of GH. Then range out the lines DA and EJ, which will meet in a point, C, which will be the one required. Any number of such may be similarly obtained to verify the work.

This problem is given in a recent number of the Vienna Engineer's Journal (*Zeitschrift des Oesterreichischen Ingenieur Verein*, 1856, p. 245) by an Austrian mathematician, who represents it as employed by practical surveyors, but as not having any known geometrical proof. He proceeds to give an analytical investigation of it, saying, "I have in vain tried to prove the problem in the synthetic way, by pure geometry." The "Theory of Transversals," however, the foundation of the "Recent Geometry," or "Geometry of Segments," (too little cultivated beyond a small circle of French geometers) will furnish a simple and perfect demonstration, as follows.

The theorem to be proved is equivalent to the assertion that if A, B, C, and D, E, F, lie respectively in two straight lines, and lines be drawn as in the figure, then will the intersections G, H, J lie in one and the same straight line.

Conceive the two given lines produced to meet in Z, beyond the limits of this figure. The triangle BFZ is so cut by the transversal CE as to give the equality

$$BJ \times FE \times ZC = JF \times EZ \times BC.*$$

The triangle AFZ, cut by CD, gives $FH \times AC \times DZ = HA \times CZ \times FD.*$
The triangle ABG, cut by CD, gives $BC \times AL \times GD = BD \times CA \times GL.*$
The triangle DEG, cut by CZ, gives $GA \times EZ \times BD = EA \times DZ \times BG.*$
The triangle DEG, cut by AF, gives $GK \times DF \times AE = KD \times EF \times AG.*$
The triangle AGK, cut by HD, gives $KD \times GL \times AH = GD \times AL \times KH.*$

Multiplying together the corresponding members of these six equations, we get a new one containing eighteen factors on each side. Of these, fifteen factors in each member can be cancelled, and we have left $BJ \times FH \times GK = JF \times BG \times KH$. This shews,† that the points G, H, J, lie in a straight line, which is a transversal to the triangle BFK.

What Poinsot said, forty years ago, that "The simple and fruitful principles of this ingenious theory of transversals deserved well to be admitted into the number of the elements of geometry," is even more true and desirable at the present time.

ART. XXIX.—*Biography of Johann Nepomuk von Fuchs;* by FRANZ VON KOBELL.

[Concluded from p. 101.]

* * * * * * *

IN 1829 Fuchs published a paper on Lime and Mortar. Some years later this was followed by his essay "On the Properties and Composition of Hydraulic Cement," which received a prize from the Academy of Sciences at Harlem.

Notwithstanding the chemical relations of lime and its carbonate had been already, as it might appear, thoroughly studied, Fuchs occupied himself anew with the processes of burning and slaking lime, and investigated the so-called half-burning and dead-burning. He thus discovered the basic carbonate of lime, and the compound of hydrate with carbonate. He discussed the properties of soluble and insoluble silica, ascribing their differences to difference of coherence, and studied the reactions of lime on silica and on the silicates in the wet way, as chiefly underlying the theory of the solidification of mortar. He con-

* By the theorem "If a straight line be drawn so as to cut any two sides of a triangle and the third side, one or all being prolonged, thus dividing them into six segments (the prolonged sides and the prolongations being taken as segments) then will the product of any three of those segments whose extremities are not contiguous, be equal to the product of the other three segments."

† By the converse of the preceding theorem.

vinced himself by numerous experiments that lime is capable of uniting in the wet way with silica and its compounds, even with such as already contain lime. The completest proof of this he found in the facts that certain insoluble silicates, and silica itself "in a certain degree of coherence," gelatinize with acids after they have been mixed for some time with lime in a moist state, and that these mixtures also increase more and more in hardness and solidity. These instructive experiments were instituted on quartz, opal, artificially prepared silica, and its gelatinous hydrate, feldspar, porcelain earth, clay, garnet, prehnite, analcime, apophyllite, &c. He confirmed the result which he had obtained twelve years before, that by this treatment a part of the alkali which may be present in silicates is set free, and he expressed the idea that this reaction might some day be employed for the preparation of potash and soda. After Fuchs had further examined common and hydraulic mortar, and the so-called cements, he recognized all the conditions which are demanded in the production of hydraulic mortar, and showed that it could be prepared from most marls, and taught how they could be tested as to their value for such a purpose. He drew attention to various marls in Bavaria, and to the ashes of the turf of her vast moors, as material for cement, and proposed that it be prepared by burning marl, using the turf as fuel.

His prize essay may be regarded as a continuation of the paper on Lime and Mortar, and sums up clearly the experimental results, with this conclusion; that the hardening of hydraulic cement depends essentially upon a chemical union of silica with lime, which gradually takes place in the wet way. Accordingly, there can be no hydraulic cement without silica, and further, there is produced a hydrated silicate or zeolitic compound. He discovered that but very few natural silicates (some volcanic products excepted) are so constituted that lime acts on them directly in the wet way, they mostly require to be burned, some of them indeed must be burned with a little lime, before they are acted on. What Fuchs had said in his academical oration with regard to the relations between chemistry and mineralogy, he thus demonstrated practically. He could hardly have been so successful in this research had he not been acquainted with both these sciences, since the latter furnished the materials for the solution of the problems that occurred to him. These results explain the advantages of burning clay as has been practised in agriculture. On this point Baron v. Liebig remarks in his "Familiar Letters on Chemistry," as follows: "These interesting facts were first observed by Fuchs at Munich; they have not only led to a most intimate knowledge of the nature and properties of the hydraulic cements, but, what is far more important, they explain the effects of caustic lime upon the soil, and guide the agricultur-

ist in the application of an invaluable means of rendering it soluble, and setting free its alkaline substances so important, nay, so indispensable to his crops."

Fuchs rendered an important service to mineralogy when in 1831 he made public his method for the quantitative separation of the protoxyd and peroxyd of iron. His method consists in the use of carbonate of lime or baryta, which precipitates the peroxyd but not the protoxyd, from hydrochloric acid solution. This process has been found further applicable to the separation of peroxyd of iron from protoxyd of manganese, of alumina from magnesia, and for precipitating other analogous oxyds. Instead of carbonate of lime or of baryta, the carbonates of magnesia, copper, zinc, and manganese may be used, and thus the separations effected in sulphuric acid solution. This method also serves for precipitating phosphoric and arsenic acids with peroxyd of iron, so that these acids may be separated and determined in this way. In presence of these acids then, this method is useless for the determination of iron. Knowing this, Fuchs sought another process on occasion of the analysis of a phosphate of iron from Bodenmais, which he named Melanchlor. He was thereby led to the discovery of the valuable method which is founded upon the fact that hydrochloric acid does not dissolve metallic copper in exclusion of air, but that it is dissolved in an acid solution of perchlorid of iron. Protoxyd of iron may also be determined if it be peroxydized. The quantity of copper in a solution, may be estimated also by the same method; the chlorid of that metal is converted into subchlorid by contact with strips of metallic copper, the loss of weight of the latter is equal to the copper originally in the solution. Fikentscher has applied this method to testing the amount of available oxygen in manganese, and I have directed the attention of copper etchers to the use of perchlorid of iron as a substitute for aqua fortis; it attacks the copper without formation of the dangerous fumes which are evolved in the old process. By this method too, Fuchs discovered the sesquioxyd of titanium, and he has shown how it may be employed in analyzing silicates containing titanic acid.

The labors of Fuchs so far as already noticed, evidence much connectedness and a systematic development the one from another; this is again manifest in his paper on amorphism presented to the Academy of Sciences in 1833.

Although the condition of amorphism had already attracted some attention,* nevertheless Fuchs first characterised it, and

* In Fuchs' Theory of the Earth (1837) the gelatinizing of fused epidote, garnet, &c. with acids, is thus spoken of—"this change can only be explained by the supposition, that on fusion, these bodies lose their crystalline and assume an amorphous condition." In Kastner's Archives, vol. v, p. 165, the writer has thus expressed himself (1825) on this matter, "the reason of this phenomena appears to lie herein, that by fusion the attractive force of the different simpler compounds of these minerals for each other, is (relatively) suspended, *with the suspension of the crystalline condition.*"

made it prominent by interesting examples. He begins by mentioning some facts from his paper on lime and mortar, viz., that powdered opal unites with lime in the wet way, and is easily soluble in boiling caustic potash solution, while the finest quartz is unattacked by lime, and dissolves with exceeding slowness in potash solution. This behavior can only have its foundation in a difference of aggregation (or solidity)—(*Zustand des Starren*), which is either crystalline, or the opposite of crystalline—amorphous. Common glass is an amorphous body, which may assume the crystalline condition by long exposure to heat, as in Reaumur's porcelain. Glass and Reaumur's porcelain have the same relation to each other as opal to quartz.

Among amorphous bodies belong obsidian, pumice, pitchstone and pearlstone (he was inclined to reckon leucite among them), also allophane, psilomelane, thraulite, &c., the fossil coals, resins and gums, gelatine, and many other substances. He instanced especially the product formed by pouring highly heated sulphur into water, which after a time recovers the crystalline structure; further examples of bodies occurring in both the amorphous and crystalline condition are charcoal and diamond, kermes and crystallized sulphid of antimony, precipitated sulphid of mercury and cinnabar. Very interesting is his remark upon *deformation*, i. e., the transition from the crystalline to the amorphous condition. He says, "In my view deformation precedes, nay, must precede every chemical synthesis. The process whereby dissimilar bodies unite to one homogeneous body, is one we can hardly hope ever to understand fully, something however is always gained, when an erroneous notion which directs away from the truth, is set aside. Such a false idea, I hold to be that, according to which, the act of chemical union consists merely in the crystalline* molecules of two or more bodies arranging themselves in juxtaposition, so that in fact a chemical product is nothing more than a very intimate mixture. My opinion is rather, that before two substances can combine they must first lay off the crystalline form ordinarily peculiar to them (become amorphous), and then are they in a condition to take on together the new form which they are inclined to assume, or to which the resultant of their innate forces disposes them. This view is sustained by the fact that crystallization acts like a repulsive force against affinity, and must be overcome before that power can exercise itself. Every inorganic body must also become amorphous before it can enter the organic kingdom, and be assimilated to an organic substance. Crystallization and life are absolutely incompatible with each other, and so soon as a substance in an organic body begins to crystallize, so soon it falls into the inor-

* The original is *gestaltet*, and might be rendered by the word *morphous*, the opposite of amorphous.—Tr.

ganic realm. The crystal is, so to speak, the boundary-stone between the two kingdoms."

Fuchs also makes the amorphous state a condition of the fitness of mineral matter for vegetable nutrition, and thereby explains the richness of volcanic soil, the fertilizing effects of many burned silicates, &c. As silica (Tabasheer) passes through the vegetable, so doubtless the phosphate and carbonate of lime pass the animal body in an amorphous state, and in the formation of shells, pearls and coral, the carbonate of lime is probably at first deposited in a gelatinous (amorphous) state.

In a later article Fuchs discussed the so-called isomerism, and pointed out the possibility of explaining it, partly at least, by the differences between the crystalline and amorphous structure. All these considerations are highly worthy of notice, and Fuchs made them the basis of certain geological views which he presented to the Academy, April 25, 1837. In this address, "On the theories of the Earth," Fuchs opposed the Plutonists, and the theory of upheavals, without however, accepting literally the doctrines of the Neptunists. He reasoned against the view that the crystalline rocks were once in a state of fusion, as follows, using granite as the illustration: If granite were once in a molten condition, then as it cooled, in the first place, quartz must have crystallized out, and would have sunk down through the still molten mass, while feldspar and mica must have crystallized at a much later stage of the cooling, as the necessary result of their different degrees of fusibility. Further, the inclusion of arsenical pyrites, sulphid of antimony, tourmaline, garnet, fluor-spar, &c., by quartz, is incompatible with the crystallization of the latter from a state of fusion. Accordingly, the doctrine of upheavals cannot be sustained. In enunciating his own views, Fuchs begins with the proposition that amorphism must precede crystallization, and assumes that originally, the solid part of the earth consisted of silica and silicates in the amorphous form, while the liquid portions were largely made up of solutions of lime and magnesia or their carbonates, in the then existing excess of carbonic acid. "This I conceive to have been the primal or chaotic condition of our globe, this may indeed have been preceded by another condition, but to this state it must have come before the formation of rocks could begin."

In this explanation, may perhaps be found a means of harmonizing and uniting the well-founded views of Fuchs, with the plutonic theories, in so far as these are also sound—how, I can indicate only, in this place. The formation of rocks began, according to Fuchs, with the silicates. The stupendous crystallization thus induced must have developed light and heat. The latter must have acquired great intensity—even that of ignition. The products were different as determined by circumstances, viz.,

granite, syenite, porphyry, mica slate, &c., which in fact, as is known, pass into each other, and may be included together under the term granitic rocks. Also at a later period members of the silicious group were formed, but not so perfectly as at first; examples are clay-slate, and many sandstones. The limestones and calciferous rocks began to be formed simultaneously with the silicious rocks, and the production of both ran parallel through all epochs, down to the most recent times. After the deposition of carbonate of lime, the vast quantities of carbonic acid which had served to hold it in solution, became the material which should especially contribute to the sustenance of organic nature. Says Fuchs "this acid had from the beginning of the creation a three-fold office; firstly to keep the carbonate of lime separated from the silicates, and for a certain time to retain it in solution; secondly to furnish the atmosphere with oxygen, and thirdly to supply carbon for the production of fossil coal and organic bodies. In recent geological times have probably been formed by their decomposition, two kinds of products, viz., bituminous, containing much hydrogen, and humus-like, containing both hydrogen and oxygen."

Fuchs notices here the objection, that there is not now enough free oxygen in the atmosphere to form carbonic acid with all the carbon of the globe. Accordingly a part of the oxygen originally present must have been devoted to other purposes, and he assumes that it was mostly consumed at a later period in the formation of gypsum. He supposes that before gypsum was formed, there existed the easily soluble hyposulphite of lime, and that it passed into gypsum by oxydation. For such a phenomenon Fuchs offers two explanations, both of which accord with chemical principles, and one of which at the same time, accounts for the presence of free sulphur in the gypsum beds. Either the hyposulphite of lime might be converted into gypsum by immediate oxydation, and the free sulphuric acid thereby formed also yield gypsum, by contact with neighboring carbonate of lime; or the hyposulphite of lime might be resolved into sulphur and sulphite of lime, and the latter pass into gypsum by absorption of oxygen.

Instead of the theory of upheaval, Fuchs proposes a theory of collapse, since by the crystallization of the amorphous masses they would assume a smaller space, and thereby cavities and breaches must be formed, which would result in dislocations, and the falling down of large bodies of rock. The half solid mass which was not crystallized might then penetrate the rifts of the neighboring rock, thus giving origin to veins and dykes. In these revolutions however Fuchs also admits certain upheavals.

In a subject like this it is naturally impossible that speculation, be throughout, founded upon positive knowledge, or be capable of control by experiment. We continually find gaps in our reasoning, and are obliged to have recourse to hypothesis. For example, with regard to the chemical relations of bodies under the influence of very high temperatures and pressures, we know indeed that these circumstances modify the ordinarily observed phenomena to a very remarkable degree; combinations and decompositions being effected of a character entirely different from those which occur under common conditions: but we are unacquainted with the precise nature of these changes, and do not know all of the processes by which a given mineral product may be formed. It need not surprise us then that Fuchs has allowed some play of the imagination in his theory of the earth, as when he assumes that our globe was once self-luminous from the light which might have been developed in the crystallization of the granitic rocks, and when he supposes that rock-masses may have been vitrified and metamorphosed by superficial electric discharges instead of subterranean fires; or, that waterspouts may perhaps have been the means of transporting erratic blocks. As an evidence however that Fuchs did not give himself up to one-sided views, he reminds us of the truism which deserves before all others to become a proverb among geologists. "The same does not always happen in the same manner."

The views of Fuchs have found many objectors. Among others Berzelius controverted them and sought to weaken his chief argument againt the assumption that the earth was originally in a state of fusion, viz., that in such case all lime must exist now as silicate and none as carbonate, because at a high temperature silica expels carbonic acid from its combinations, by asserting that the density of the vast quantity of aqueous vapor in the atmosphere at that time would have been sufficient to balance the tension of carbonic acid, so that it could remain in combination with lime even in presence of silica.* To this Fuchs replied,† that at the fusing point of silica, a temperature far higher than that of melted platinum, the tension of carbonic acid must be so exalted that the pressure of the atmosphere could not have prevented its escape, especially since the tendency of silica to combine with lime must have facilitated this separation. We see how impossible it is in this kind of study to avoid building upon hypothesis, because we do not know even approximately what is the melting point of silica, and still less are we acquainted with the conditions involved in the fusion of carbonate of lime, or what was the atmospheric pressure in those primeval times.

* Berzelius Jahresbericht, 19, p. 742.

† In Dr. A. Wagner's Geschichte der Urwelt. 1845.

It is perhaps possible to show that the silicates of lime might have been at a later period, again decomposed by the action of the excess of carbonic acid then existing in the atmosphere, and with vastly greater readiness than happens now under the present pressure; but here is not the place to proceed with this discussion. I must however mention that it is to be regretted that Berzelius, who in opposing Fuchs, recognized him as an able chemist, did not take the trouble to read through the paper in question, and thus avoid raising an objection to his theory of the formation of gypsum, which were it well founded implied a gross error on the part of Fuchs, but which was the error of Berzelius himself. The greater the authority a scientific man acquires, the more careful and conscientious should be his criticisms, because the multitudes always follow such a man blindly, and are glad thereby to save the trouble of investigating for themselves; and yet it is precisely these who are most ready to sound the trumpet, and thus error instead of truth is often promulgated to the injury of science and her followers.

I should lead you too far should I give an analysis of the numerous shorter papers of our departed fellow-laborer, e. g., his observations on graphite, &c., on the sesquioxyd of tin and purple of cassius, the discovery of iodine in the salt spring of Hall, the analyses of triphyline, iron-apatite, &c., &c. They abound in interesting statements and have borne fruit to science as well as to the arts.

In scientific research as in common life Fuchs was conscientious and honorable. He was free from pedantry, and through all his frequent corporeal sufferings maintained a calm serenity. He recognized with joy the merits of others, and he accorded approbation to earnest effort; but superficialness and charlatanism excited his indignation and sarcasm. In discourse he was clear and connected, and knew how to interest hearers in his subject. Weakness of the chest prevented him from speaking without frequent interruption, his manner however was forgotten in the matter. His mineralogical lectures were published in 1842. The chemical part especially, is full of choice observations, and thus it forms a valuable complement to the ordinary text-books. Fuchs was no friend of complicated methods, even when they were thus planned for the purpose of obviating sources of error, for he considered the errors involved in the practical execution of such methods. He was accustomed to say, "over-sharp does not cut, and over-pointed does not sting."

I have often been surprised at the interest which he manifested even in his latest years in scientific intelligence, and at the attention he bestowed on matters which it would be thought, could have no longer any value in the estimation of one so old. He looked forward calmly and with christian resignation to the time

of his dissolution, and his spirit was strong and unclouded to the last.—He died on the fifth of March 1856. Although his nature was phlegmatic rather than excitable, he could warm with the fullest enthusiasm, in the discussion of scientific subjects, especially when as frequently happened, his own labors had been misunderstood or misrepresented, or when his results were ignored by those who entered the fields of inquiry which he had explored. Although his scientific achievements have been sometimes underestimated, on the other hand they have received the highest appreciation from the most illustrious philosophers of his day. He was constituted member of very numerous learned societies, and of the academies at Berlin and Vienna. He was decorated with the highest Bavarian orders of Knighthood, and under circumstances of especial honor received the Prussian order of the Red Eagle. In the ministerial despatch accompanying the latter occur the following words; "His Majesty the King of Prussia on occasion of the reception of Vicats' work on the formation of Hydraulic Cement, through the Prussian embassy at Paris, has become aware of the distinguished merits of the Royal Bavarian Chief Mining Counsellor and Professor, Dr. Fuchs,—merits surpassing even those of Vicat,—especially in the purely scientific part of the subject. In recognition, &c."

On his seventieth birthday, which was celebrated as a festival by his numerous disciples and friends, Fuchs uttered these modest words: "Had I enriched science with only *one* established principle, I could receive these demonstrations of honor without a sense of shame, but towards this I have only made some slight contributions." He said still further, "remembering the old saying, *nisi utile est quod facimus stulta gloria*, I have sought sometimes to give my labors a practical direction—I will not however say by this, that science is useful only when she enters the affairs of life and brings us material gains. All science is a product of mind and reacts on mind to its development; this of itself is its greatest use, because the expansion of our spiritual nature is the chiefest good that can be attained. Only a shallow brain, only a narrow or perverted reason, can behold in nature the monster Materialism."

While the memory of Fuchs will be perpetuated by his discoveries that have passed into and enriched our practical life, it will not the less be held in reverence in the history of science, for he truly belonged among her CONSECRATED ONES.

ART. XXX.—*Researches on the Ammonia-cobalt Bases;* by WOLCOTT GIBBS and F. A. GENTH. Part I.

[Reprinted from the ninth volume of the Smithsonian Contributions to Knowledge by special permission of the Secretary, who has also permitted the use of the original woodcuts.]

THE facility with which alkaline solutions of many metallic protoxyds absorb oxygen from the air, attracted the attention of chemists at an early period. The protosalts of iron, manganese and cobalt, are particularly remarkable in this respect. In the presence of an excess of the fixed caustic alkalies and their carbonates, salts of the protoxyds of these metals are more or less rapidly converted into basic salts of their higher oxyds. A similar effect appears to be produced by all of the more powerful fixed bases, while it is remarkable that neutral or acid solutions of the same salts are oxydized much more slowly, an effect which is perhaps owing to the tendency which per-salts in general exhibit to become basic, and to the influence which an excess of acid exerts in producing neutral or acid compounds.

Ammonia acts like potash and soda in causing the oxydation of solutions of iron and manganese. In the case of these two metals either basic salts or hydrates of the peroxyds are formed, which contain no ammonia, at least in chemical combination. With salts of protoxyd of cobalt the result of the oxydation is very different. The sesquioxyd of cobalt at the instant of its formation unites with a certain number of equivalents of ammonia so as to produce a conjugate base of which ammonia forms an integral portion. The new base partakes in some measure of the properties of the alkalies, the peculiar character of the salts of cobalt being wanting. It is with this class of bases that we have at present to deal.

The earliest observations which we possess upon the oxydation of the salts of cobalt are due to Leopold Gmelin, who, in a memoir, published in 1822,* described the changes of color which are produced when ammoniacal solutions of the chlorid, sulphate, and nitrate of cobalt are exposed to the air. The solutions under these circumstances absorbed oxygen and became brown, and Gmelin considered it probable that they contained a cobaltic acid. Dingler,† who subsequently endeavored to determine the amount of oxygen absorbed, inferred that the cobaltic acid consisted of one equivalent of cobalt and two equivalents of oxygen, since the brown solution gave with sulphid of ammonium a black precipitate of bisulphid of cobalt. Winkelblech‡ denied

* Neues Journal der Chemie und Physik. Neue Reihe, V, 235.
† Kastner's Archiv, xviii, 249.
‡ Annalen der Pharmacie, xiii, 148, 253.

the existence of a metallic acid in the solution, but though his memoir contained many interesting and valuable contributions to our knowledge of the oxyds of cobalt, it threw no light upon the true nature of the ammoniacal compounds, except by establishing in them the existence of sesquioxyd of cobalt. The subject was next investigated by Beetz,* who analyzed an ammoniacal sulphate and nitrate of sesquioxyd of cobalt formed during the direct oxydation of ammoniacal solutions. These analyses led to the formulas $Co_2O_3.3SO_2+3NH_3+NH_4O$, and $Co_2O_3.3NO_5+3NH_3+NH_4O$, but as the substances employed were not crystallized, and as the analytical methods were difficult to execute, but little reliance could be placed in the results. Beetz, however, considered the sesquioxyd of cobalt in these compounds as playing the part of an acid, the ammonia being present as a salt of ammonium.

The oxydation of ammoniacal solutions of various salts of cobalt was also observed by Rammelsberg,† and the products of the action in several cases analyzed. None of the formulas obtained, however, appear to belong to well defined and distinct compounds.

A memoir published by one of ourselves, in 1851,‡ contained the first distinct recognition of the existence of perfectly well defined and crystallized salts of ammonia-cobalt bases; in fact we have not been able to trace in any earlier paper even the idea of the existence of such a class of compounds. The results made public in this paper had been obtained by the author, in Marburg, in 1847, had been at that time freely though verbally communicated, and a suite of the salts obtained had been left in the laboratory at Giessen. Want of opportunity prevented a complete and systematic investigation, particularly from the analytical point of view. The memoir in question contained, however, besides several analyses, an accurate description of the two bases now to be described under the names of Roseocobalt and Luteocobalt. Though the analyses were from necessity not sufficiently complete and extended to fix the constitution of the bases in question, yet the fact is indisputable that this memoir contained, not merely the first announcement of the existence of ammonia-cobalt bases, but also a scarcely less accurate and complete description of two of these bases than any which has since appeared.

As its title states, the memoir in question was intended simply as a preliminary notice; circumstances, however, prevented a resumption and continuation of the subject. In a paper pub-

* Pogg. Ann., lxi, 494, 480, 490.

† Pogg. Ann., xlviii, 208. xliv, 268.

‡ Nordamerikanischer Monatsbericht für Natur. und Heilkunde, 1. Januar. 1851. Vorläufige Notiz über gepaarte Kobaltverbindungen von Dr. Friedrich August Genth.

lished in 1851,* Claudet described with some detail the properties of the chlorid of Purpureocobalt, and the mode of obtaining it, as well as a few other ammonia-cobalt salts. With the exception, however, of more complete analyses, the memoir in question contained nothing which is not to be found in the previously published paper above alluded to. In two notices communicated to the Academy of Sciences† in the same year, Frémy announced as his own, the discovery of a class of compounds containing cobalt and ammonia, and produced by the oxydation of ammoniacal solutions of protosalts of cobalt. In the following year his complete memoir appeared.‡ In this Frémy describes anew the ammonia-salts of protoxyd of cobalt, first obtained by H. Rose, passes then to the description of two new classes of compounds discovered by himself, and named by him Oxy-cobaltiaque and Fusco-cobaltiaque, and finally describes at some length the principal salts of Genth's two bases, the constitution of which he correctly determines. Frémy appears not to have been aware that these two bases had been described in a manner little less complete than his own two years before the appearance of his memoir. The chlorid of Luteocobalt and its platinum salt have also been described and analyzed by Rogojski,§ and what we now term the chlorid of Purpureocobalt, by Gregory,‖ who corrected the analyses of Frémy.

The researches of Claus¶ on the ammonia-iridium and ammonia-rhodium bases established the existence of compounds of these metals exactly analogous to Roseocobalt and its salts, and chemists will look with impatience for the publication of his results in detail. Recently Weltzien has published some theoretical views on the constitution of the ammonia-cobalt bases which possess much interest.

The salts of Xanthocobalt were discovered in November, 1852, by W. G., and the principal results which are contained in the present memoir were communicated to the American Association for the Advancement of Science, at its meeting in Cleveland in August, 1853. The formulas of several of the more remarkable bases are also given in a Report on the recent progress of organic chemistry, read before the same association, at its Providence meeting in August, 1855. The nomenclature of the ammonia-cobalt bases proposed by Frémy is so simple and convenient that we have adopted and extended it to meet every case. We have, however, considered it desirable to drop the

* Phil. Mag., ii, 253, and Ann. de Chimie et de Physique, xxiii, 483.
† Comptes Rendus, xxxii, 509, 808.
‡ Ann. de Chimie et de Physique, xxxv, 257.
§ Journal für praktische Chemie.
‖ Ann. der Chemie und Pharmacie, lxxxvii, 125.
¶ Bulletin de l'Académie de St. Petersburg, 1855, xiii, 97, quoted in Handwörterbuch der reinen und angewandten Chemie, vi, 843.

terminal syllable "iaque," employed by Frémy, not merely because it is not an English termination, but because by omitting it we obtain shorter and more convenient words. Thus, we say Roseocobalt and Luteocobalt, instead of Roseo-cobaltiaque and Luteo-cobaltique, or Roseo-cobaltia and Luteo-cobaltia, which are the English equivalents. The shorter names, as will hereafter appear, also agree better with our own theoretical views, since we consider the compounds in question conjugate metals and not ammonias.

With the view of making the description of our salts as complete as possible, we have followed the excellent example of Frémy, and referred the colors of these substances to Chevreul's chromatic scale. Frémy had the advantage of Chevreul's own determinations. We have employed, for the purpose, the chromatic scales recently published in Paris by Digeon, and which appear to be reliable; in any event they give *some* precision to determinations of color. As we have found that very many of the salts of the ammonia-cobalt bases exhibit a well marked dichroism, we have in most cases examined the light reflected from layers of crystals, by Haidinger's dichroscopic lens, and have given the colors of the ordinary and extraordinary images as obtained in this way. As a curious physical result, we may here mention that, in general, the cobalt color predominates in the ordinary image.

We are indebted to Prof. Dana for the determination of the systems to which many of our crystals belong, and of their principal forms, as well as for our figures, and embrace this opportunity of expressing our grateful acknowledgement of his valuable assistance.

METHODS OF ANALYSIS.

The accurate quantitative determination of the different elements which enter into the constitution of the ammonia-cobalt bases and their salts, is attended with great difficulties. We have in general found it necessary to study out with much labor the methods of analysis proper to be used in each particular case; and it has been only after many trials that we have at length been able to obtain accurate results. Before proceeding to the description of the compounds in question, it may therefore be proper to state the analytical methods employed.

Cobalt.—The determination of the cobalt in these salts may, in most cases, be very easily and accurately effected by the following process. A weighed portion of the salt is gently heated in a deep platinum crucible, with a quantity of pure and strong sulphuric acid sufficient to moisten the whole mass. Some effervescence is generally produced by the addition of the acid, but there is no danger of loss if the crucible be sufficiently large,

and if the heat be applied only after the first action of the acid is over. The mixture is to be gently heated over a spirit lamp, until the excess of the acid, sulphate of ammonia, and other volatile matters have been expelled. During the whole time of heating, the cover of the crucible must be so placed as to prevent the possibility of loss by spattering, and at the same time to permit the escape of volatile matters. When, however, the quantity of acid has not been too great, the whole process goes on very quietly to the end, when the mass becomes dry. The heat is finally to be raised, for an instant, to low redness, the cover of the crucible being quickly lifted off and then replaced. The crucible is then to be allowed to cool and weighed, when the quantity of cobalt may easily be calculated from the weight of the dry and pure sulphate. After the weighing, the mass in the crucible must be carefully examined. It should have a fine rose color, and be perfectly soluble in warm water, leaving no black residue. In case this is observed, which happens only when the heat has been too high, a drop of sulphuric acid and a few drops of oxalic acid may be added, and the whole evaporated to dryness, and again ignited. When, however, there is much oxyd of cobalt present, it is better to reject the analysis at once. With a little care and practice the operation succeeds almost invariably, and the result, as we shall hereafter show, leaves nothing to be desired in point of accuracy. When chlorine is present in the salt to be analyzed, a little free chlorine is sometimes found among the products of the action of the sulphuric acid, and the platinum crucible is slightly acted upon. In such cases we usually add a little oxalate of ammonia to the salt before dropping the acid upon it. The quantity of salt to be taken for analysis may vary from three to five decigrammes; when more is used, there is apt to be some loss from effervescence. In consequence of the small quantities of substance employed, the weighings must be as accurate as possible. In calculating the weight of the cobalt from that of the sulphate, we have the advantage of determining one substance from another with an equivalent more than twice as high.

In certain cases, as, for example, when phosphoric acid, chromic acid, &c., are present, the above method cannot be employed. In such compounds we have found it advantageous to separate the cobalt as a hydrate of the sesquioxyd, by boiling the salt with a solution of caustic potash, washing the precipitate thoroughly, and estimating the ignited precipitate as Co_6O_7, or as metallic cobalt after reduction by hydrogen. Frémy justly observes that this ignited oxyd usually contains potash; but an accurate result may always be obtained by washing it well with boiling water after the ignition, and weighing a second time. It

is remarkable that Frémy asserts that cobalt may be accurately estimated in the form of sulphate, in consequence of the stability of this salt, while the direct application of the method, as we have described it above, appears to have escaped him entirely.

Hydrogen.—We have in almost all cases determined hydrogen directly by combustion with chromate of lead, metallic copper being placed in the anterior part of the tube. In the case of the nitrates, however, an excess of hydrogen in the result is almost unavoidable, because it is impossible, even with freshly reduced copper, to decompose completely the great quantity of oxyds of nitrogen formed during the combustion. In other cases this effect is much less marked, and the hydrogen determinations are at least as accurate as in ordinary organic analyses.

Chlorine.—The accurate determination of the chlorine in the ammonia-cobalt salts is very difficult. Nitrate of silver, it is true, precipitates chlorine from most of its combinations in these salts, but the precipitation is never complete, because the chlorid of silver is somewhat soluble in the ammonia-cobalt chlorids, forming with them peculiar double salts. By long boiling with free nitric acid in the solution, nearly all the chlorine may be determined as chlorid of silver, but very accurate results cannot be obtained in this manner. The best method consists in igniting the chlorid with lime in a combustion tube, in the manner usually practised with organic bodies. In some cases, however, we have obtained very good results by decomposing the solution of the chlorid by sulphurous acid, or by boiling the solution of the salt until it is completely decomposed, adding sulphurous or nitrous-nitric acid to reduce the sesquioxyd of cobalt, and then precipitating with silver. The process is, however, always troublesome, and requires much time and great care.

Carbon.—This element is best determined by the usual process of organic analysis. In consequence, however, of the very large quantity of oxyds of nitrogen, which are always produced during the combustion of these salts, we have found it very advantageous to employ a method first suggested, we believe, by Winkelblech, and which consists in mixing with the oxyd of copper a quantity of finely divided metallic copper, in the form in which it is obtained by reducing the oxyd by hydrogen. In this manner the formation of the oxyds of nitrogen may be completely prevented. Great care must, however, be taken when it is wished to determine hydrogen at the same time with carbon, because, copper reduced from the oxyd by hydrogen, always contains water, which it is difficult to separate.

Nitrogen.—No element has presented such difficulties as nitrogen. We have found it impossible to obtain results within two or three per cent of the truth by employing the old methods of analysis, that of Dumas for instance. The quantity of nitric

oxyd formed during the combustion is surprising, and it is absolutely impossible to get rid of it by means of ignited metallic copper, placed in front of the combustion tube. Will and Varrentrapp's method with soda lime is inapplicable, because one equivalent of ammonia is always decomposed by the equivalent of oxygen set free in the reduction of sesquioxyd to protoxyd of cobalt. Good results could not be obtained by boiling the salts with caustic alkalies, collecting the ammonia in chlorhydric acid, and determining it by bichlorid of platinum. Even after the reduction of the sesquioxyd of cobalt to protoxyd by means of sulphurous acid, this method was found unreliable. The improvements made by Simpson in the absolute determination of nitrogen by volume at last furnished us with a reliable process; and nearly all the analyses in this memoir were executed by his method. The improvement introduced by Simpson consists essentially in mixing oxyd of mercury with the oxyd of copper employed to effect the combustion. The vapor of metallic mercury completely decomposes the oxyds of nitrogen, and any excess of free oxygen is absorbed by means of metallic copper. By this method we have analyzed most of our compounds without special difficuly, though we have often found it necessary to employ a much larger proportion of oxyd of mercury than is recommended by Simpson. One class of ammonia-cobalt bases have, however, been the source of frequent analytical failures, and of great loss of time and material. We refer to the salts of Xanthocobalt, a base containing deut-oxyd of nitrogen, and giving off this gas at a gentle heat, below that at which oxyd of mercury is decomposed. Simpson's method has not always been found accurate, since even when a very large amount of oxyd of mercury is employed there is frequently much nitric oxyd in the nitrogen collected for measurement. In many cases the simple admixture of a large proportion of metallic copper with the oxyd, as recommended by Winkelblech, has been found to give most excellent results. It is proper also to state here that, in consequence of difficulties in obtaining proper apparatus with which European chemists do not have to contend, we have, in the majority of cases, measured the volume of nitrogen in the old way, using, however, very accurately graduated tubes for collection, and correcting with great care for temperature and pressure. We have also found it advantageous to operate upon quantities of substance sufficient to yield at least two hundred cubic centimetres of gas, since in this way the error of reading becomes extremely small.

Sulphuric acid.—This acid cannot be accurately determined in the ammonia-cobalt salts by direct precipitation with chlorid of barium. In almost all cases, a great apparent excess of acid is obtained, and this may amount to five per cent, even when the

sulphate of baryta appears to have been completely washed. We have, therefore, in all cases preferred to decompose the salt to be analyzed, by boiling it with a little ammonia. After complete precipitation of the sesquioxyd of cobalt, chlorhydric acid is to be added to reduce and dissolve the oxyd, when the sulphuric acid may be directly thrown down by chlorid of barium. Even with these precautions, our results are not unfrequently two-tenths or three-tenths of one per cent too high, almost never too low.

Oxalic acid.—The ordinary methods for the quantitative estimation of this acid fail entirely with the class of salts under consideration. A solution of terchlorid of gold is reduced only after very long and tedious boiling, and then incompletely. Even after previous reduction of the cobalt to the form of protoxyd, the method is found to be very inconvenient and inaccurate. The conversion of the oxalic into carbonic acid by oxydation, and its determination from the weight of this last, gave no better results, inasmuch as the oxydation is effected with difficulty. We have therefore in all cases had recourse to the ultimate organic analysis, which alone gives reliable results.

The methods employed in the determination of other substances will be described, when necessary, in treating of particular compounds.

ROSEOCOBALT.

The description of the salts of Roseocobalt forms, upon the whole, the most convenient starting point in a statement of the results of our investigation. These salts are in general easily obtained, and the products of their decomposition include several of the other bases, which we shall have occasion to describe. They are almost all well crystallized, and are in general nearly insoluble in cold water, soluble without decomposition in warm water slightly acidulated, but easily decomposed when the neutral solutions are boiled, a hydrated hyper-oxyd of cobalt being thrown down, while free ammonia is given off. The salts of Roseocobalt have a purely saline, not metallic taste; their color varies, being sometimes dull or brick-red, and sometimes cherry-red. They are usually dichrous, though a few of them do not exhibit this property in a marked degree. Heat decomposes the dry salts readily, the final products of the decomposition being usually ammonia, a salt of ammonium and a salt of protoxyd of cobalt. Intermediate products are, however, sometimes formed, as we shall hereafter see. Thus in many cases the salts of Roseocobalt on boiling yield salts of Luteocobalt, which then, by continued boiling, are completely decomposed. The salts of Roseocobalt may almost always be prepared by the direct oxydation of ammoniacal solutions of salts of

protoxyd of cobalt, but the particular circumstances, which accompany the formation of each one, will be best considered in treating of the separate compounds. Roseocobalt is a triacid base.

CHLORID OF ROSEOCOBALT.

An ammoniacal solution of chlorid of cobalt absorbs oxygen readily from the air, becomes at first brown and then gradually passes through various shades of color to a deep red. The red solution leaves upon a filter a quantity of hydrate of sesquioxyd of cobalt, which is sometimes almost inappreciable, sometimes in comparatively large amount. In one experiment, in which we employed perfectly pure chlorid of cobalt and pure ammonia, there was no deposit whatever of oxyd. In this case, however, no chlorid of Roseocobalt, but only chlorid of Purpureocobalt was formed. When impure materials are used the precipitate is abundant, and contains many of the impurities of the substances employed, as well as much sesquioxyd of cobalt. The rate at which oxygen is absorbed varies much with the degree of concentration of the solution, with the temperature, with the quantity of ammonia present, and with the extent of liquid surface exposed to the air. Frequent agitation of the solution materially shortens the time required for complete oxydation, and the same effect is produced by passing a current of oxygen directly through the liquid, which soon becomes brown and subsequently red. As a general rule, the first effect of the oxydizing action is to give the liquid a brown color, the layer next the surface being the first to change its tint. The brown color then passes gradually into a deep red, and the oxydation is complete, when the whole mass of liquid has the color of red Burgundy wine.

The presence of chlorid of ammonium is not necessary in this process; a large quantity of this salt in the solution often gives a lilac or purple precipitate as the oxydation advances, but this is composed principally of the chlorid of Purpureocobalt. As will be seen from the above, the chlorid of Roseocobalt is not always formed during the oxydation of an ammoniacal solution of chlorid of cobalt. On the contrary, it often happens that not a trace of this salt can be obtained from the oxydized solution, which contains only the chlorid of Purpureocobalt. We have observed the absence of the chlorid of Roseocobalt only in solutions which had been oxydized in a warm room, or during the summer season. This fact, taken in connection with the facility with which heat transformes solutions of Roseocobalt into those of Purpureocobalt, renders it, to say the least, extremely probable, either that a comparatively high temperature prevents the formation of the chlorid of Roseocobalt entirely, or else that this salt is converted into chlorid of Purpureocobalt as fast as it is formed in the solution.

To obtain the chlorid of Roseocobalt from the oxydized solution, cold and strong chlorhydric acid is to be added to it, the slightest elevation of temperature being carefully avoided. A brick-red precipitate is thrown down, which is to be washed with strong chlorhydric acid and then with ice-cold water, thrown upon a filter, and dried by pressure, great care being taken to operate at as low a temperature as possible.

As the formula of the chlorid of Roseocobalt is $5NH_3.Co_2Cl_3+2HO$, its formation by the oxydation of the ammoniacal solution of chlorid of cobalt may be explained by the equation

$$6CoCl+10NH_3+3O=2(5NH_3.Co_2Cl_3)+Co_2O_3.$$

In those cases in which no sesquioxyd of cobalt is precipitated, we may suppose that the sesquioxyd unites directly with ammonia, as represented by the equation

$$3CoCl+15NH_3+3O=2(5NH_3.Co_2Cl_3)+5NH_3.Co_3O_3.$$

On adding an excess of chlorhydric acid to such an oxydized solution, $3(5NH_3.Co_2Cl_3)$ must be formed, which satisfactorily explains the precipitation of the brick-red chlorid by the acid.

Frémy assigns to the brown substance, which is the first product of the oxydation, the formula $4NH_3.Co_2O_3$. We have not yet been able to obtain this substance in a condition fit for analysis, and Frémy does not consider the formula, which he proposes, as by any means established.

It will be seen from the above that, in the formation of the chlorid of Roseocobalt, the elements of ammonia unite with sesquioxyd or sesquichlorid of cobalt at the instant that these are formed by the absorption of oxygen from the air. Claus has recently shown that the sesquichlorid of rhodium* unites directly with five equivalents of ammonia to form a chlorid exactly analogous to the chlorid of Roseocobalt, and having the formula $5NH_3.Rh_2Cl_3$. We have made various experiments to determine whether sesquioxyd of cobalt once formed could unite directly with ammonia. A solution of chlorid of ammonium was poured upon freshly prepared sesquioxyd of cobalt, strong ammonia-water added, and the whole allowed to stand for some time in a closed bottle and in a rather dark closet. Even after many weeks, however, only traces of chlorid of Roseocobalt could be detected. A quantity of sesquioxyd of cobalt was dissolved in strong acetic acid, and to the solution chlorid of ammonium and ammonia-water added. In this case chlorid of Roseocobalt was formed after a few days, but it is doubtful whether its formation was not due to the oxydation of a small quantity of protoxyd of cobalt in the sesquioxyd employed. In another experiment, strong ammonia was added to

* Since the above was written, Claus has extended his observation to the sesquichlorid of iridium, which forms a similar base with five equivalents of ammonia.

freshly prepared sesquioxyd of cobalt, and the whole allowed to stand for several weeks, after which time it was boiled with chlorhydric acid, and considerable quantities of chlorid of Purpureocobalt, Luteocobalt, and Praseocobalt, were obtained. This experiment leaves no doubt that the ammonia-cobalt bases can be prepared by the direct action of ammonia upon sesquioxyd of cobalt, though this mode of preparation is not economical.

The chlorid of Roseocobalt may also be prepared by adding cold and strong chlorhydric acid to a completely oxydized solution of the ammoniacal nitrate or sulphate of cobalt. A brick-red precipitate is formed in either case, which must be purified by repeated washing with chlorhydric acid. Strong chlorhydric acid also precipitates the chlorid from solutions of the sulphate and nitrate of Roseocobalt. In all these cases, however, it is difficult to obtain the chlorid in a perfectly pure state.

The chlorid of Roseocobalt is usually precipitated as a brick-red powder, which, under the microscope, appears to be composed of indistinct granular crystals. It may be purified, though with difficulty, by solution in ice-cold water and spontaneous evaporation in the cold. The salt is soluble in cold, as well as in hot water, with a dark-red but not a violet-red color, the portions still undissolved becoming lilac or purple before dissolving. The most remarkable property of this salt is the facility with which it is converted into chlorid of Purpureocobalt. The hot solution yields, on cooling, small but brilliant crystals of the latter chlorid; in fact even solution in warm water converts a portion of chlorid of Roseocobalt into chlorid of Purpureocobalt, as may easily be observed by the change of color. This transformation is, however, far more striking when a solution of chlorid of Roseocobalt is boiled with a little chlorhydric acid: the solution speedily changes its color from a dull-red to a beautiful violet-red, and on cooling deposits an abundant crystallization of chlorid of Purpureocobalt. There is in this case a direct conversion of Roseocobalt into Purpureocobalt, an isomeric radical; the reactions of the violet-red solution being entirely different from those of the same solution previous to boiling with acid, except in one or two particulars, to be pointed out hereafter. The dry chlorid of Roseocobalt is also slowly converted into chlorid of Purpureocobalt by keeping, changing its color to violet-red; in this case, however, the change is not complete, even after a long time, unless heat be applied. The formula of the chlorid of Purpureocobalt, as we shall hereafter show, is

$$5NH_3.Co_2Cl_3.$$

This differs from that of the chlorid of Roseocobalt only by containing no water of crystallization. The change which takes place in the conversion of one chlorid into the other does not,

however, consist in the mere loss of water. As we shall show, the chlorid of Roseocobalt corresponds to a triacid oxyd, while that of Purpureocobalt yields a biacid oxyd. It is to be carefully borne in mind, that the substance which we have called chlorid of Roseocobalt is not the chlorid of Roseo-cobaltiaque of Frémy, Claudet, and other chemists who have studied the subject. To the chlorid described by Frémy under the name of chlorid of Roseocobaltiaque we have given the name of chlorid of Purpureocobalt. The necessity of this change of name has arisen from the fact that hitherto two different bases have been confounded, the chlorid of Purpureocobalt having been considered as the chlorid corresponding to the sulphate and nitrate of Roseocobalt.

The chlorid of Roseocobalt is dichrous, the ordinary being paler than the extraordinary image; both are rose-red, with a faint brownish orange tint.

Chlorid of Roseocobalt, as already mentioned, has the formula

$$5NH_3.Co_2Cl_3+2HO,$$

as the following analyses show:

0·7291 grs. gave 0·4235 grs. of sulphate of cobalt = 22·10 per cent of cobalt.
0·6247 grs. gave 0·3619 grs. " " = 21·99 " "
0·9834 grs. gave 0·5742 grs. chlorid of silver = 39·57 " chlorine.
1·8112 grs. gave 2·9095 grs. " " = 39·71 " "
2·2390 grs. gave 1·2829 grs. water = 6·37 " hydrogen.
1·4993 grs. gave 0·8784 grs. " = 6·50 " "
1·2235 grs. gave 282 c. c. nitrogen at 22°·5 C. and 766^{mm}·82 (at 23° C.) = 254·91 c. c. at 0° and 760^{mm} = 26·16 per cent.

The formula requires—

	Calculated.	Found.	
Cobalt, - -	21·97	21·99	22·10
Chlorine, - -	39·66	39·57	39·71
Hydrogen, -	6·33	6·37	6·50
Nitrogen, - -	26·08	26·16	——

With respect to this formula, it must be remarked that it is extremely difficult to obtain this chlorid perfectly free from chlorid of Purpureocobalt, into which it is so easily converted. The uncertainty, however, will concern only the number of equivalents of water. The chlorid of Roseocobalt combines with the chlorids of the electro-negative metals to form well defined salts. The platinum salt, which we have not yet fully examined, appears to have the formula

$$5NH_3.Co_2Cl_3+3PtCl_2+8HO.$$

A neutral solution of the chlorid of Roseocobalt is easily decomposed by boiling, with evolution of ammonia, and precipitation of a black powder. This powder is probably a hydrate of the magnetic oxyd, Co_3O_4+xHO, but we have deferred its ex-

amination to the second part of our memoir. The reactions of the chlorid of Roseocobalt are as follows:

Terchlorid of gold gives no precipitate at first, but after standing a lilac or purple precipitate, which is probably merely the chlorid of Roseocobalt.

Bichlorid of platinum gives a pale orange red precipitate.

Chlorid of mercury gives a pale rose or flesh-colored flocky precipitate.

Ferridcyanid of potassium gives beautiful orange-red oblique rhombic crystals.

Cobaltidcyanid of potassium gives fine red crystals.

Ferrocyanid of potassium gives a cinnamon, passing to a chocolate brown precipitate.

Oxalate of ammonia gives a brick-red precipitate of small granular crystals.

Neutral chromate of potash gives no precipitate.

Bichromate of potash gives a dark brick-red precipitate.

The following reactions, which were obtained with a solution of the hydrated nitrate of Roseocobalt may also be introduced in this place.

Pyrophosphate of soda gives a dull rose-red precipitate soluble in an excess of the precipitant to a clear red liquid, which in a few minutes solidifies to a mass of fine rose-red needles.

Picrate of ammonia gives a fine bright orange red precipitate soluble in hot water.

Iodid of potassium gives no precipitate either with the chlorid or nitrate.

The precipitate with chlorid of mercury is readily soluble in chlorhydric acid, and the solution after standing gives beautiful small granular crystals of a brownish red color.

The reactions which are peculiar to the sulphate of Roseocobalt will be described when speaking of that salt.

SULPHATE OF ROSEOCOBALT.

An ammoniacal solution of sulphate of cobalt absorbs oxygen readily from the air, becoming at first brown and then dark red. The time required for complete oxydation varies remarkably. The process is sometimes complete in a few days, but often requires many weeks. From the perfectly oxydized solution, sulphuric acid cautiously added usually throws down the sulphate of Roseocobalt as a bright red crystalline powder, which, after washing with cold water, is readily purified by solution and crystallization, a very small quantity of acid being added to prevent decomposition.

The sulphate of Roseocobalt is, however, not always the only salt formed under these circumstances. In some cases in which the ammoniacal liquid was allowed to stand several months until

there remained only a dry mass of red crystals, warm water dissolved out a red salt in small quantity, much more sobuble than the sulphate of Roseocobalt, and giving different and very characteristic reactions. In other cases, and especially when a little chlorid of cobalt was originally present, warm water dissolved out another sulphate, crystallizing in octahedra of an orange-red color, the examination of which is not yet complete.

We are unable to confirm Frémy's assertion that sulphuric acid precipitates from oxydized ammoniacal solutions of sulphate of cobalt, an *acid* sulphate of Roseocobalt, having the formula

$$5NH_3.Co_2O_3, 5SO_3+5HO.$$

The salt precipitated under these circumstances is merely the neutral sulphate, as repeated analyses have shown, and as the crystalline form at once proves. The formula of the neutral sulphate is

$$5NH_3.Co_2O_3, 3SO_3+5HO,$$

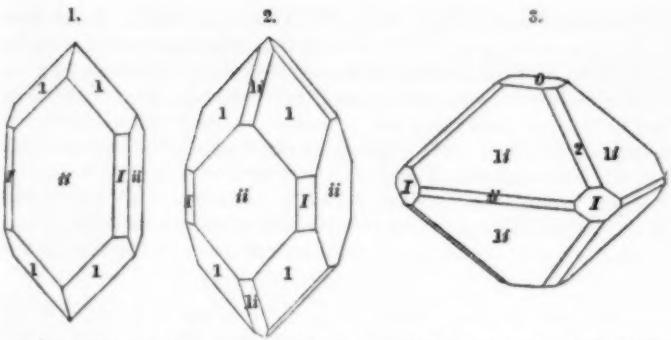
as the following analyses show:

0·8160 grs. gave 0·3800 grs. sulphate of cobalt = 17·72 per cent cobalt.
0·8272 grs. gave 0·3869 grs. " " = 17·79 " "
0·2760 grs. gave 0·2908 grs. sulphate of baryta = 36·11 per cent sulphuric acid.
0·5731 grs. gave 0·6074 grs. " " = 36·38 " " "
1·4925 grs. gave 0·8250 grs. water = 6·14 " hydrogen.
1·2840 grs. gave 0·7109 grs. " = 6·15 " "
1·2108 grs. gave 220·5 c. c. nitrogen at 18° 4 C. and 761^{mm}·23 (at 18°·9) = 201·97 c. c. at 0° and 760^{mm} = 20·95 per cent nitrogen.
1·0404 grs. gave 194·2 c. c. nitrogen at 20°·5 C. and 754^{mm}·37 (at 20°·5) = 174·67 c. c. at 0° and 760^{mm} = 21·08 per cent nitrogen.

The formula as above stated requires

	Eqs.	Calculated.		Found.		Mean.
Cobalt, -	2	59·0	17·71	17·72	17·79	17·75
Sulphuric acid,	3	120·0	36·03	36·11	36·38	36·24
Hydrogen, -	20	20·0	6·00	6·14	6·15	6·14
Nitrogen, -	5	70·0	21·02	20·95	20·08	21·01
Oxygen, -	8	64·0	19·24	——	——	18·86
		333·0	100·00			100·00

The sulphate of Roseocobalt has a fine cherry-red color. The light reflected from a layer of the crystals when analyzed by the dichroscopic lens, gives a rose-red ordinary, and an orange-red extraordinary image. The dichroism is very distinct. In this, as in our other observations upon dichroism, the reflected rays examined made an angle of about 60° with the normal, but no material variations of color could be observed by changing the angle of incidence. The exact color of the crystals is, according to Chevreul, the second red $\frac{2}{1^0}$ths. The crystals of sulphate of Roseocobalt belong to the dimetric or square prismatic system, as determined by Prof. Dana. The observed forms are represented in figs. 1, 2, and 3. The measured angles are as follows:



$1:1 = 107° 20'$; $1:ii = 126° 20'$; $ii:1i = 137° 21'$; $O:1i = 132° 35'$ (calc. 132° 39'); $a = 1{\cdot}0866$.

Prof. Dana remarks that the angles are very close to those of Cerasine; and also to those of Scheeletine or tungstate of lead, if $1i$ be $\frac{1}{2}$ and 1 be $1i$.

The sulphate of Roseocobalt is nearly insoluble in cold water, but is soluble in much boiling water, and crystallizes readily as the solution cools. By slow evaporation, it may be obtained in large crystals, which, however, seldom exhibit very perfect faces. Ammonia in dilute solution dissolves the sulphate, giving a fine purple solution, from which the salt crystallizes unchanged. The neutral solution is readily decomposed by boiling, ammonia being evolved, and a dark brown precipitate of the hydrated magnetic oxyd of cobalt, $Co_3O_4 + 3HO$, thrown down, while sulphate of Luteocobalt remains in solution. The decomposition in this case extends to the sulphate of Luteocobalt also, so that much less than one equivalent of this salt is obtained for two equivalents of the sulphate of Roseocobalt decomposed.

Strong ammonia poured upon dry sulphate of Roseocobalt usually changes its color almost immediately from a red to a buff yellow, while the liquid itself becomes red. The buff colored substance formed in this case, is the sulphate of Luteocobalt; the red solution contains sulphate of Roseocobalt.

When dry sulphate of Roseocobalt is carefully heated in a porcelain or platinum crucible, ammonia is evolved, and there remains a lilac-red mass, which contains sulphate of Luteocobalt, sulphate of Purpureocobalt, and a leek-green crystalline substance which we have called provisionally Praseocobalt.

We shall speak of all these reactions more fully when treating of the sulphate of Luteocobalt.

A current of the red gas which arises from the action of nitric acid upon starch, and which probably consists chiefly of NO_4, converts an acid, neutral, or ammoniacal solution of sulphate of Roseocobalt into one of the nitrate of Xanthocobalt.

A solution of sulphurous acid gently heated with sulphate of Roseocobalt gives, in a few minutes, an orange precipitate of a substance containing ammonia, sesquioxyd of cobalt, sulphurous and sulphuric acid, and which we shall describe fully in the second part of our memoir.

Strong sulphuric acid digested with sulphate of Roseocobalt yields, under some circumstances, sulphate of ammonia and sulphate of Luteocobalt. In other cases it yields the acid sulphate of Purpureocobalt. By double decomposition with salts of barium the sulphate of Roseocobalt yields the other salts of this base.

The reactions of the sulphate are somewhat different from those of the chlorid, as will be seen from the following statement.

Ferridcyanid of potassium gives no precipitate at first, but after two hours very distinct and well defined small augitic crystals.

Cobaltidcyanid of potassium behaves in a precisely similar manner, giving red crystals.

Neutral chromate of potash gives no precipitate. The bichromate gives none at first, but after two or three hours, groups of reddish brown needles.

We shall hereafter state our reasons for believing that in certain cases there is a conversion of the triacid Roseocobalt in the sulphate of this base, into the biacid Purpureocobalt.

ANHYDROUS NITRATE OF ROSEOCOBALT.

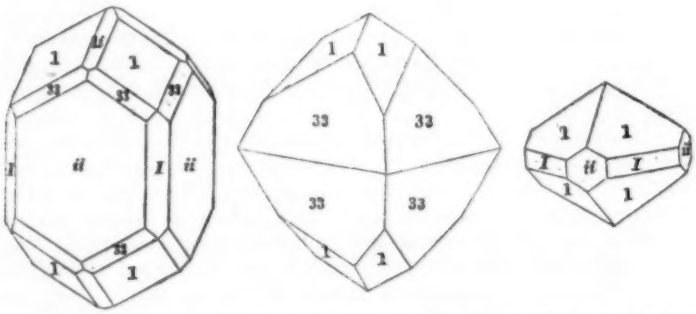
The ammoniacal solution of nitrate of cobalt absorbs oxygen very readily from the air, and the oxydation is usually complete after a few days. As a general rule, a considerable quantity of nitrate of Luteocobalt is formed under these circumstances, and being insoluble in the ammoniacal liquid, forms a bright yellow crystalline precipitate upon the bottom and sides of the vessel. During the process of the oxydation, crystals of the compound described by Frémy as the nitrate of Oxycobaltiaque are frequently formed in some quantity, but these disappear at a later stage of the oxydation, when the liquid takes a deep wine-red color. The crystals of nitrate of Oxycobaltiaque were first observed by Leopold Gmelin. We have not particularly examined or analyzed them, though Frémy's analyses do not appear to us satisfactory.

The dark-red liquid formed under these circumstances contains nitrate of Roseocobalt. When nitric acid is added to this solution, a brick-red precipitate is thrown down, which is the hydrated nitrate of Roseocobalt. This nitrate is readily soluble in water, and exists unchanged in the solution, but by boiling with nitric acid, the solution yields a fine violet-red crystalline precipitate of the anhydrous nitrate of Roseocobalt. The pres-

ence of nitrate of ammonia facilitates the oxydation and formation of nitrate of Roseocobalt, but is not indispensable.

The preparation of pure nitrate of Roseocobalt is attended with difficulty, as the precipitated crystalline nitrate almost always contains a little nitrate of Luteocobalt. It is best to dissolve the crude nitrate in water, to which a little ammonia has been added, to filter and allow the solution to evaporate spontaneously. After some days, large and well defined crystals of the nitrate are formed, while the bottom of the evaporating vessel is covered with minute red crystals of the same salt. The difference between the appearance of the large and small crystals is so great that we suspected a difference in their constitution. Analysis and the behavior of the two kinds towards reagents, showed, however, no difference. A marked variation in the color of the large and small crystals of the same substance is very commonly observed in the ammonia-cobalt compounds, and might easily lead to erroneous conclusions. The nitrate of Roseocobalt is readily prepared by decomposing a solution of the chlorid with nitrate of silver, but the solubility of the chlorid of silver in chlorid of Roseocobalt renders it somewhat difficult to obtain a pure salt in this manner. Nitrate of copper also gives nitrate of Roseocobalt with chlorid of copper, when mixed with an equivalent proportion of chlorid of Roseocobalt, but the purification is difficult. Finally, a pure nitrate may be prepared by double decomposition of nitrate of baryta and sulphate of Roseocobalt. The anhydrous nitrate of Roseocobalt, when in large crystals, has a fine red color, which, according to Chevreul's determination, as given by Frémy, is the first red $\frac{2}{15}$. The crystals are dichrous; the ordinary image is clear rose red, the extraordinary image bright red. According to Prof. Dana, this salt, like the sulphate, crystallizes in forms belonging to the dimetric system. Figs. 4 and 6 represent some of the more usual combinations, fig. 5 is a very rare form, which was obtained only once.

4. 5. 6.



1 : 1 (over the base) = 82° 40′. Whence 0 : 1 (not observed) = 138° 20′; I : 1 = 131° 40′.

Ammonia dissolves the nitrate with a fine purple red tint, and the salt usually crystallizes unchanged from the solution, though sometimes the hydrous nitrate is obtained. In cold water the nitrate is rather insoluble, though more soluble than the sulphate. Hot water dissolves it rather more easily; but the solution, unless it be acid, is quickly decomposed, and this effect is very speedily produced by boiling. The products of the decomposition in this case are a dark-brown oxyd of cobalt, and a solution containing the nitrate of Luteocobalt and nitrate of ammonia. The quantity of Luteocobalt is small in comparison with that of the nitrate of Roseocobalt employed.

When heated, the nitrate of Roseocobalt explodes, though not with violence. A black anhydrous oxyd remains, which is probably Co_2O_3. The reaction in this case is easily explained, if we remark that the oxygen in the nitric acid is exactly sufficient to form water with the hydrogen of the ammonia. The simplest equation representing the reaction is

$$5NH_3.Co_2O_3, 3NO_5 = Co_2O_3 + 8N + 15HO.$$

In point of fact, however, the decomposition is less simple, as red vapors are always evolved.

When a current of NO_4 is passed through a solution of nitrate of Roseocobalt a rapid absorption takes place, and after a short time crystals of nitrate of Xanthocobalt are deposited.

A solution of sulphurous acid converts the nitrate of Roseocobalt, at first into an orange-colored compound containing SO_2, and afterward reduces this completely to nitrate and sulphate of cobalt and nitrate of ammonia.

Nitrate of Roseocobalt has the formula

$$5NH_3.Co_2O_3, 3NO_5,$$

as the following analyses show:

0·2308 grs. gave 0·1081 grs. sulphate of cobalt = 17·82 per cent cobalt.
0·1272 grs. gave 0·0599 grs. " " = 17·92 " "
0·1448 grs. gave 0·0681 grs. " " = 17·90 " "
0·9370 grs. gave 0·3915 grs. water = 4·64 per cent hydrogen.
0·6632 grs. gave 0·2862 grs. " = 4·79 " "
2·7312 grs. gave 1·1258 grs. " = 4·57 " "
0·5564 grs. gave 168 c. c. nitrogen at 24° C. and 766^{mm}·31 (at 24°·5) = 150·54 c. c. at 0° and 760^{mm} = 33·98 per cent.
0·7400 grs. gave 213 c. c. nitrogen at 13°·5 C. and 764^{mm}·28 at (13°·8) = 200·55 c. c. at 0° and 760^{mm} = 34·03 per cent.

The formula above mentioned requires

	Eqs.	Calculated.		Mean.	Found.		
Cobalt,	2	59·0	17·87	17·88	17·82	17·92	17·90
Hydrogen,	15	15·0	4·55	4·60	4·64	4·79	4·57
Nitrogen,	8	112·0	33·93	34·01	33·98	34·03	——
Oxygen,	18	144·0	43·65	43·51	——	——	——
		330·0	100·00	100·00			

When nitrate of Roseocobalt is dissolved in water containing much nitrate of ammonia and a little ammonia, and the solution is allowed to evaporate spontaneously, beautiful purple-red scaly crystals separate. These crystals cannot be purified by recrystallization, as they are decomposed by solution in water. When boiled with chlorhydric acid there is copious effervescence and a purple-red solution is obtained, which appears to contain the chlorid of Purpureocobalt. The empirical formula of the scaly nitrate appears to be $5NH_3.Co_2O_3, 2NO_5+7HO$. From the effervescence with muriatic acid we are disposed to consider it $4NH_3.Co_2O_3, NO_5+NH_4O, NO_5+6HO$, but further investigation is required before we can pronounce with certainty on this point.

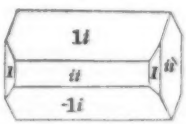
HYDROUS NITRATE OF ROSEOCOBALT.

When ammonia is added in excess to a solution of the nitrates of cobalt and of ammonia and the solution is exposed to the air, oxydation takes place with considerable rapidity, and as we have already stated when speaking of the anhydrous nitrate, the solution becomes dark purple-red, while yellow scales of the nitrate of Luteocobalt are more or less abundantly deposited upon the bottom of the vessel. When the red liquid is boiled with nitric acid in excess, a dark crimson precipitate of nitrate of Roseocobalt is formed, while a portion of the same salt remains in solution. It has hitherto been supposed from these facts that the anhydrous nitrate of Roseocobalt is a direct product of the oxydation of the ammoniacal liquid. This, however, is not the case. If the oxydized liquid be filtered from the nitrate of Luteocobalt and allowed to evaporate spontaneously, very fine large oblique rhombic crystals are formed, which are the hydrous nitrate of Roseocobalt.

The crystals of this nitrate belong to the monoclinic or oblique rhombic system, according to Prof. Dana's determination. The observed forms are *I*, 1*i*, *ii*, −1*i*, *i*$\bar{i}$, or in other symbols, ∞, 1-∞, ∞-∞, —1-∞, ∞-$\bar{\infty}$. Fig. 7. The angles are

7.

$I : I = 103°$
$1i : ii = 136°$
$-1i : ii = 140° 30'$
$1i : 1i = 96° 30'$ and $83° 30'$



The hydrous nitrate of Roseocobalt is readily soluble even in cold water; the hot neutral solution is very easily decomposed with evolution of ammonia and precipitation of a black powder. The addition of a few drops of nitric acid prevents the decomposition. An excess of nitric acid added to a cold solution of the nitrate produces a brick-red precipitate, which is readily sol-

uble in cold water, and which is the unchanged salt. The solution has a dark brick-red color, and exhibits all the reactions of the chlorid of Roseocobalt. When boiled with an excess of nitric acid for some time, the brick-red color gradually becomes violet-red, and there remains at last a beautiful violet precipitate, which is the anhydrous nitrate of Roseocobalt. From this it appears that, in some cases at least, and particularly when nitrate of ammonia is present during the oxydation, the hydrous nitrate of Roseocobalt is the first product of the oxydation of an ammoniacal solution of nitrate of cobalt, and that it is the action of nitric acid upon this salt which converts it into the anhydrous nitrate. The nitrate of Roseocobalt obtained by direct oxydation may be recrystallized by adding to its solution a few drops of nitric acid and allowing it to stand a few days for spontaneous evaporation. In this manner beautiful crystals are obtained, adhering to the bottom of the evaporating vessel, and mixed with a dull-red matter in crystalline crusts, which exhibits the same reactions with the large and clear crystals, and appears to have the same constitution, though upon this point we cannot speak with certainty at present.

We consider the formula of the hydrous nitrate of Roseocobalt as most probably

$$5NH_3.Co_2O_3, 3NO_5+2HO$$

as the following analyses indicate:

0·8265 grs. gave 0·3703 grs. sulphate of cobalt = 17·05 per cent cobalt.
0·5275 grs. gave 0·2370 grs. " " = 17·09 " "
0·8012 grs. gave 217·8 c. c. nitrogen at 11°·5 C. and 761^{mm}·48 (at 11°·4 C.) = 206·05 c. c. at 0° and 760^{mm} = 32·30 per cent.
0·7667 grs. gave 207 c. c. of nitrogen at 14° C. and 766^{mm}·56 (at 14°·2 C.) = 194·91 c. c. at 0° and 760^{mm} = 31·92 per cent.

The formula requires

	Eqs.	Calculated.	Found.	
Cobalt, - -	2	16·95	17·05	17·09
Nitrogen, - -	8	32·18	32·30	31·92

It is true that the analyses here agree with the formula as well as can be reasonably expected. We have, however, found in other crystals from the same mass 17·82, 17·86, 17·92, 18·06 per cent cobalt, numbers which agree much better with the formula of an anhydrous nitrate, having the same formula as the nitrate of Roseocobalt already described, which contains 17·87 per cent. In any event, the doubt appears to be simply with respect to the quantity of water in the salt, the ratio of the equivalents of cobalt and nitrogen being as 1 to 4, or 2 to 8. We shall return to this point at another time.

OXALATE OF ROSEOCOBALT.

The oxalate is precipitated from the chlorid almost immediately by the addition of a solution of oxalate of ammonia. From a solution of the nitrate it is deposited much more slowly, often only after some hours, and sometimes in remarkably distinct and well formed crystals. The oxalate as first thrown down may be purified by solution in ammonia-water and recrystallization by spontaneous evaporation. The salt then forms beautiful prismatic crystals, which are nearly insoluble in water, and which have a fine cherry-red color, resembling the crystals of sulphate of Roseocobalt. The crystals are dichrous, the ordinary image being pale violet, while the extraordinary image is dark rose-red. The precipitated oxalate has a dull brick-red color. According to Prof. Dana, the crystals of oxalate of Roseocobalt belong to the right rhombic or trimetric system, the observed forms being a rhombic prism of about 101° 48′, with a brachydome of 108° 54′.

The constitution of the oxalate of Roseocobalt is represented by the formula

$$5NH_3.Co_2O_3,\ 3C_2O_3+6HO$$

as the following analyses show:

0·5504 grs. gave 0·2625 grs. sulphate of cobalt = 18·15 per cent.
0·3325 grs. gave 0·1585 grs. " " = 18·14 "
1·5381 grs. gave 0·6170 grs. carbonic acid = 32·82 per cent oxalic acid.

The formula requires

	Eqs.	Calculated.	Found.	
Cobalt, - -	2	17·87	18·15	18·14
Oxalic acid, - -	3	32·73	32·82	——

COBALTIDCYANID OF ROSEOCOBALT.

This beautiful salt is precipitated from a solution of the chlorid or hydrous nitrate of Roseocobalt, by a solution of cobaltidcyanid of potassium. It may be prepared with equal facility from a solution of the chlorid of Purpureocobalt, which under these circumstances, as we conceive, undergoes a direct change into a salt of the triacid Roseocobalt. The cobaltidcyanid is usually precipitated at once in the form of cherry-red prismatic crystals, which, so far as it is possible to judge from their appearance under the microscope, belong to the oblique rhombic or monoclinic system, much resembling some of the simpler forms of augite. The salt is very insoluble in cold water; hot water readily decomposes it. It forms an extremely characteristic test for the salts of Roseocobalt in general, as well as for the chlorid of Purpureocobalt, but, as already remarked, it is precipitated from the sulphate of Roseocobalt only after some hours. The crystals are usually remarkably large when com-

pared with the mass of liquid from which they are thrown down. They are more distinct in form the more slowly the precipitation takes place. The salt has the formula

$$5NH_3.Co_2Cy_3+Co_2Cy_3+3HO.$$

as the following analyses show:

0·1924 grs. (from chlorid of Purpureocobalt) gave 0·1540 grs. sulphate of cobalt = 30·46 per cent cobalt.
0·7150 grs. (from chlorid of Roseocobalt) gave 0·5755 grs. sulphate of cobalt = 30·63 per cent cobalt.
0·8111 grs. (from chlorid of Roseocobalt) gave 272 c. c. of nitrogen at 10° C. and 761^{mm}·99 (at 10° C.) = 259·48 c. c. at 0° and 760^{mm} = 40·18 per cent.

The formula requires

	Eqs.	Calculated.	Found.	
Cobalt, - -	4	30·57	30·63	30·46
Nitrogen, - -	11	39·89	40·18	

The analyses of the ferridcyanid of Roseocobalt give additional evidence of the correctness of the formula adopted for this salt.

FERRIDCYANID OF ROSEOCOBALT.

The ferridcyanid is formed like the cobaltidcyanid by adding a solution of ferridcyanid of potassium to one of chlorid or nitrate of Roseocobalt or chlorid of Purpureocobalt. A very beautiful orange-red precipitate is thrown down in distinct and usually extremely well-defined crystals, which under the microscope, exactly resemble those of the corresponding cobalt salt. The crystals exhibit a remarkable dichroism, the ordinary image being of a fine purple rose color, while the extraordinary image is bright orange red. The crystals are insoluble in cold water; hot water easily decomposes them, ammonia being evolved, while a dark-brown precipitate is thrown down. Heat decomposes the dry salt very gradually and uniformly, and leaves a black residue which contains much carbon. We availed ourselves of this fact to determine accurately the sum of the cobalt and iron in the salt, by first decomposing it by heat, then burning off the carbon in a gentle current of oxygen, and finally reducing the mixed oxyds of cobalt and iron in a current of hydrogen. The formula of this salt is

$$5NH_3.Co_2Cy_3+Fe_2Cy_3+3HO$$

as the following analyses show:

0·3613 grs. gave 0·1086 grs. metallic iron and cobalt = 30·05 per cent.
1·5028 grs., burnt with oxyd of copper and oxygen, gave 1·0302 grs. carbonic acid = 18·69 per cent carbon.

The formula requires

	Eqs.	Calculated.	Found.
Cobalt and iron, - -	4	30·02	30·05
Carbon, - - -	12	18·79	18·69

There can be no reasonable doubt that this salt is isomorphous with the corresponding cobalt salt. Like the latter it is an extremely valuable test for the salts of Roseocobalt and for certain salts of Purpureocobalt.

OXYD OF ROSEOCOBALT.

The oxyd of Roseocobalt exists only in solution. It is obtained either by decomposing the chlorid by oxyd of silver, or by adding baryta-water to a cold solution of the sulphate; the latter method is the better one, because the chlorid of silver is soluble in solutions of the chlorid of Roseocobalt. The solution as thus obtained is red, has an alkaline non-metallic taste and reaction, and is very easily decomposed. By standing in the air it absorbs carbonic acid and forms a carbonate.

MAGNETIC OXYD OF COBALT.

In connection with the salts of Roseocobalt we may perhaps with propriety describe the peculiar oxyd of cobalt, which is, in some cases at least, one of the products of their decomposition. The hydrated oxyd which is precipitated by boiling the neutral salts of Roseocobalt with an alkaline solution is considered by Frémy as a hydrate of the sesquioxyd, and he attributes to it the formula Co_2O_3, HO. According to the same chemist, all the other ammonia-cobalt bases give this hydrate by boiling with solutions of the alkalies. It does not appear probable that the oxyd obtained by boiling the neutral solution should have a different constitution. We have however found that the dark-brown oxyd obtained by boiling a solution of sulphate of Roseocobalt, and afterward washing and drying the precipitate in the air, has the formula

$$Co_3O_4+3HO$$

as the following analyses show:

I. 0·4430 grs. gave 0·6990 grs. sulphate of cobalt = 60·05 per cent of cobalt.
II. 0·9269 grs. gave 0·1672 grs. water (ignited with chromate of lead) = 18·03 per cent.
III. 0·7150 grs. ignited in hydrogen gas gave 0·3010 grs. water, which in connection with the 2nd analysis gives 21·38 per cent oxygen in the oxyd of cobalt.

The formula requires

	Eqs.		Calculated.	Found.
Cobalt, - -	3	88·5	60·00	60·05
Oxygen, - - -	4	32·0	21·69	21·38
Water, - -	3	27·0	18·30	18·03
		147·5	100·00	99·46

Frémy's formula requires 64 per cent of cobalt. Claudet gives also the formula Co_3O_4+3HO as probable, but without analyses. On the other hand, it is possible that the different salts, not only

of Roseocobalt but of the other similar bases, may give different oxyds by decomposition. We propose to examine this point more fully hereafter.

The hydrate above mentioned and analyzed is a very dark-brown powder, which dries to a black mass with a gummy lustre. The powder is dark brown. Oxalic acid dissolves it to a green solution, without evolution of gas, but this is decomposed by heating. Chlorhydric acid also dissolves the oxyd, with evolution of chlorine and formation of the protochlorid.

We have already mentioned that the anhydrous magnetic oxyd of cobalt is sometimes obtained during the decomposition of the chlorid of Roseocobalt by heat. We are, however, not able to state precisely under what circumstances this occurs; either water or the oxygen of the air must take part in the decomposition, since the chlorid contains no oxygen. The anhydrous oxyd occurs in the form of small steel-gray octahedra, which are very hard, and which can only be dissolved by long heating with sulphuric acid, or by fusion with sulphate of potash. Nitric, chlorhydric, and nitro-muriatic acids have no decided action upon them.

1·6425 grs. of this oxyd gave 1·2059 grs. of metallic cobalt = 73·41 per cent.
1·6425 grs. ignited in hydrogen gave 0·4879 grs. water = 25·91 per cent oxygen.

The formula Co_3O_4 requires

	Eqs.		Calculated.	Found.
Cobalt, - -	3	88·5	73·44	73·41
Oxygen, - -	4	32·0	26·56	25·01
		120·5	100·00	99·32

This oxyd has recently been described by Schwarzenberg, who obtained it by igniting chlorid of cobalt with free access of air, until the chlorine is expelled. It is, therefore very probable that in the decomposition of chlorid of Roseocobalt by heat, the chlorid of cobalt is first produced, and then decomposed in the manner observed by Schwarzenberg.

With respect to the black sulphid which is thrown down from solutions of the ammonia-cobalt bases by sulphid of ammonium, it can scarcely be doubted that this is the bisulphid, as Claudet's analyses lead directly to the formula CoS_2, corroborating the results obtained by Dingler already alluded to.

PURPUREOCOBALT.

The salts of Purpureocobalt are often found among the direct products of the oxydation of ammoniacal solutions of cobalt. They are often formed from the salts of Roseocobalt by heating or by boiling with strong acids, the cobalt passing, as we conceive, from one modification to another. The salts of Purpureo-

cobalt are also formed in great abundance by the action of acids upon salts of Xanthocobalt, and we are disposed to think that they may also occur, though rarely, among the products of the decomposition of salts of Luteocobalt.

The salts of Purpureocobalt are distinguished by a fine violet-red or purple color, which is common to nearly all of them, and which is very different from the comparatively dull red of the salts of Roseocobalt. They are in general somewhat less soluble than the compounds of Roseocobalt, and crystallize, for the most part, in well defined crystals. When neutral they have a purely saline, non-metallic taste.

Heat readily decomposes the salts of this base; the final products of the decomposition are the same as in the case of the salts of Roseocobalt, but intermediate products are often formed. The neutral solutions are readily decomposed by boiling, the products of the decomposition being a black or dark-brown oxyd of cobalt and a salt of ammonium, free ammonia being given off. In some cases, however, salts of Luteocobalt are intermediate products of this decomposition.

All the salts of Purpureocobalt by long boiling with an excess of chlorhydric acid yield the chlorid.

CHLORID OF PURPUREOCOBALT.

The substance which we shall describe under the name of chlorid of Purpureocobalt is the same as that to which Frémy gave the name of chlorid of Roseocobaltiaque. In the course of our investigations it at length became clear that, under the name of salts of Roseocobalt, the compounds of two perfectly distinct bases have hitherto been confounded. It became, therefore, necessary to devise a new name. The purple color of the salts which correspond to the chlorid now to be described, led us to adopt the name of Purpureocobalt for the radical of these salts, as more appropriate than Roseocobalt, which we have retained for most of the salts to which it was originally applied. Such a change is to be regretted; it could not, however, have been avoided, without an introduction of two entirely new names.

We have already stated that the chlorid of Purpureocobalt is often a product of the direct oxydation of an ammoniacal solution of the chlorid of cobalt exposed to the air. In these cases it is sometimes mixed with chlorid of Roseocobalt, and sometimes forms the entire product of the oxydation. We believe that the temperature at which the process of oxydation goes on is the condition which determines the character and the amount of the chlorid which is formed during the oxydation. The chlorid of Roseocobalt is, in our view, the first product of the oxydation under all circumstances. At a moderately high tem-

perature, however, the chlorid passes as fast as it is formed into chlorid of Purpureocobalt, which may thus be the only final product of the oxydation, or may be mixed with variable proportions of the chlorid of Roseocobalt.

In one experiment made during the summer season, and in which chemically pure chlorid of cobalt and ammonia were employed, the process of oxydation went on very slowly, without the precipitation of any trace of sesquioxyd of cobalt. The liquid had a dull purple color, and gave with reagents no precipitates or reactions to indicate the presence of chlorid or oxyd of Purpureocobalt or Roseocobalt. On boiling with chlorhydric acid, however, the chlorid of Purpureocobalt was thrown down in abundance, and no other substance could be detected in the supernatant liquid. In this case the oxydized liquid gave no precipitate with chlorhydric acid in the cold, but the cold solution, after some hours standing, deposited distinct crystals of chlorid of Purpureocobalt. We believe that in this case a combination of the oxyd and chlorid existed in the solution, so that, as we have already suggested in speaking of the chlorid of Roseocobalt, the oxydation itself would be expressed by the equation

$$6CoCl+15NH_3+3O=5NH_3.Co_2O_3+2(5NH_3.Co_2Cl_3).$$

If we admit that the oxyd and chlorid of Purpureocobalt as thus formed are actually in combination so as to form a sort of oxychlorid, and are not merely mechanically mixed, we may perhaps explain, why no precipitates of salts of Purpureocobalt are obtained in the oxydized liquid, since the reagents added might not be able to overcome the affinity between the oxyd and chlorid. It is easy to see that by boiling with chlorhydric acid, the combination of oxyd and chlorid will give the chlorid alone, since we may have the equation

$$5NH_3.Co_2O_3+2(5NH_3.Co_2Cl_3)+3HCl=3(5NH_3.Co_2Cl_3)+3HO.$$

We have already mentioned that the chlorid of Roseocobalt is readily converted into chlorid of Purpureocobalt, by boiling with chlorhydric acid, or even by gently heating its solution. This circumstance explains why only the chlorid of Purpureocobalt is obtained by boiling a completely oxydized ammoniacal solution of chlorid of cobalt, even when this solution contains only Roseocobalt, or a mixture of Roseocobalt and Purpureocobalt. It also enables us to understand why all writers upon the ammonia-cobalt bases, up to the period of the present investigation, entirely overlooked the chlorid of Roseocobalt, and consequently described the salts of that base, as if they corresponded to, and contained the same radical as chlorid of Purpureocobalt.

It is not necessary to add chlorid of ammonium to the ammoniacal solution of chlorid of cobalt, in preparing the chlorid of Purpureocobalt. It is, however, advantageous to do so, because, the oxyd of Purpureocobalt is converted by it as fast as formed into the chlorid, and the formation of the oxychlorid is prevented. To prepare the chlorid of Purpureocobalt in a pure state from the oxydized liquid, it is only necessary to boil this with an excess of chlorhydric acid. A crimson powder is thrown down, while the supernatant liquid becomes nearly colorless, provided, at least, that a pure salt of cobalt was employed, and that the oxydation was complete. The mother liquor is to be poured off and the precipitate dissolved in a large quantity of boiling water, to which enough chlorhydric acid has been added to render the solution distinctly acid. On cooling, the solution gives small but beautiful crystals of the chlorid, almost perfectly pure. A second crystallization usually removes all traces of impurity. It is not, however, necessary to use a pure chlorid of cobalt in preparing the chlorid of Purpureocobalt. Any commercial oxyd will answer, even when arsenic, nickel, iron, &c., are present. On the other hand, it is easy to prepare a perfectly pure chlorid of cobalt, by heating the chlorid of Purpureocobalt in a porcelain crucible until vapors of ammonia and chlorid of ammonium cease to be given off. The pure chlorid of cobalt thus obtained, is remarkable for its beauty of color, the anhydrous chlorid forming pale blue talcose scales, while the solution and the crystals obtained from this have a very fine violet-red tint.

The chlorid of Purpureocobalt may be prepared by other methods. One of the most interesting of these is, by the action of strong chlorhydric acid upon a salt of Xanthocobalt. It is almost a matter of indifference which salt of Xanthocobalt is employed. As, however, the nitrate is, perhaps, most easily obtained in a pure state, it is usually most advantageous to employ this. The nitrate has the formula

$$NO_2.5NH_3.Co_2O_3, 2NO_5+HO.$$

On boiling with chlorhydric acid, the salt is slowly converted from a brown-yellow to a lilac-purple powder, which is insoluble in the supernatant acid liquid. After boiling strongly for an hour or two, almost all the original salt is decomposed, NO_2 is given off in abundance during the boiling, while a lilac colored uncrystallized mass remains at the bottom of the flask. The supernatant liquid is to be poured off, and boiling water added to the insoluble portion. A brown-yellow or dark sherry wine colored solution is usually formed, which is again to be poured off, and the washing repeated till the liquid has a clear purple color. The red mass is then to be dissolved in boiling water, to

which a little chlorhydric acid has been added, and filtered. On cooling, the chlorid of Purpureocobalt crystallizes in small brilliant crystals, which must be repeatedly recrystallized to separate all traces of impurity. The washings, on boiling with chlorhydric acid, yield a fresh portion of the chlorid. The reaction which takes place under these circumstances may be expressed by the equation

$$NO_2.5NH_3.Co_2O_3, 2NO_5+3HCl=NO_2+2NO_5, HO+5NH_3.Co_2Cl_3+HO.$$

As already remarked, the chlorid or sulphate of Xanthocobalt may be employed in a precisely similar manner, and also yield the chlorid of Purpureocobalt. When the sulphate is used, however, the resulting chlorid is apt to retain sulphuric acid with much obstinacy, and can with difficulty be freed from it.

Another method of preparing the chlorid of Purpureocobalt, consists in boiling the chlorid or nitrate of Roseocobalt with chlorhydric acid. This method is very convenient, and yields a very pure chlorid.

The chlorid of Purpureocobalt may also be prepared by boiling the acid sulphate of this base with chlorhydric acid. In this case, however, as in all others in which sulphuric acid is present in the solution, the chlorid should be boiled with a little chlorid of barium, and repeatedly recrystallized, to separate traces of the isomorphous sulphate of Roseocobalt formed at the same time.

The chlorid of Purpureocobalt has a beautiful violet-red or purple color, and is dichrous, the ordinary ray being colorless, while the extraordinary ray has a rich violet-red tint. Its solution is violet-red. The salt is nearly insoluble in cold water, but is soluble without decomposition in boiling water to which a few drops of chlorhydric acid have been added. From this solution it separates, on cooling, in very brilliant small crystals, which are simpler in form, the purer the solution from which they have crystallized. The crystals belong to the square prismatic or dimetric system, according to Prof. Dana, and not to the regular system, as stated in previous memoirs. The observed forms are the octahedron and first and second prism. $P.\infty P\infty.P\infty$. The angles in Dana's notation are (see fig. 1):

1 : 1 over the base = 114° 8′; over the top = 65° 52′.
1 : 1 over the terminal edge = 107°—107° 20′ (calculated 107° 12′).
O : 1 (calculated) = 122° 56′.
O : 1*i* (calculated) = 132° 30′.
1*i* : 1*i* over the base = 95°; over the top = 85°.
$a = 1{\cdot}0916$.

The crystals are usually small but extremely well formed; those which are obtained from solutions containing a little chlorid of mercury most frequently exhibit the planes of the first

and second prism, and are larger than those which separate from pure solutions. From these measurements, it appears that the chlorid of Purpureocobalt is isomorphous with the sulphate of Roseocobalt. This isomorphism is the more remarkable, inasmuch as a precisely similar case occurs with the chlorid and sulphate of Luteocobalt, between which there is a similar difference of constitution. Thus we have

$$5NH_3.Co_2Cl_3 = 5NH_3.Co_2O_3, 3SO_3 + 5HO$$
$$6NH_3.Co_2Cl_3 = 6NH_3.Co_2O_3, 3SO_3 + 5HO.$$

From this it appears that in both cases we have the crystallographic equallity

$$3Cl = O_3, 3SO_3 + 5HO.$$

The density of the crystals of chlorid of Purpureocobalt, as taken in alcohol, is 1·802 at 23° C.; the atomic volume of the chlorid is consequently 139·0.

The chlorid of Purpureocobalt has the formula

$$5NH_3.Co_2Cl_3$$

as appears from the following analyses:

0·5215 grs. gave 0·3230 grs. of sulphate of cobalt = 23·58 per cent cobalt.
0·4962 grs. gave 0·3073 grs. " " = 23·57 " "
0·8514 grs. gave 0·5279 grs. " " = 23·55 " "
1·4116 grs. gave 0·8732 grs. " " = 23·55 " "
0·7550 grs. gave 0·4105 grs. water = 6·04 per cent hydrogen.
0·6116 grs. gave 0·3412 grs. " = 6·19 " "
0·6124 grs. gave 0·3365 grs. " = 6·10 " "
1·4184 grs. gave 0·7800 grs. " = 6·11 " "
1·6636 grs. gave 2·8540 grs. chlorid of silver = 42·40 per cent chlorine.
0·4754 grs. gave 0·8200 grs. " " = 42·49 " "
0·1966 grs. gave 0·3365 grs. " " = 42·31 " "
0·4972 grs. gave 0·8553 grs. " " = 42·52 " "
0·5963 grs. gave 143 c. c. nitrogen at 18° C. and 772^{mm}·4 (at 18°·4 C.) = 113·19 c. c. at 0° and 760^{mm} = 28·05 per cent nitrogen.
0·5542 grs. gave 134 c. c. nitrogen at 19° C. and 766^{mm}·56 (at 19°·4 C.) = 123·26 c. c. at 0° and 760^{mm} = 27·93 per cent nitrogen.
0·6036 grs. gave 168·16 c. c. nitrogen at 752^{mm}·60 and 15° C, h = 93^{mm}·5, t = 15°·6 C, = 135·08 c. c. at 0° and 760^{mm} = 28·11 per cent nitrogen.
0·5755 grs. gave 160·39 c. c. nitrogen at 771^{mm}·39 and 15° C, h = 112^{mm}·7, t = 15° C, = 128·86 c. c. at 0° and 760^{mm} = 28·12 per cent nitrogen.

The nitrogen in these as in all our analyses was moist. Hence we have

	Eqs.		Theory.	Mean.	Found.			
Cobalt,	2	59	23·55	23·56	23·58	23·57	23·55	23·55
Chlorine,	3	106·5	42·50	42·48	42·49	42·31	42·52	42·40
Hydrogen,	15	15	5·98	6·11	6·04	6·19	6·10	6·11
Nitrogen,	5	70	27·97	28·01	28·05	27·93	28·12	28·11
		250·5	100·00	100·11				

The agreement of these analyses leaves no reasonable doubt that the true formula of the chlorid of Purpureocobalt is $5NH_3.Co_2Cl_3$, as first correctly determined by Rogojski, and subse-

quently by Gregory. Frémy gives in addition one equivalent of water, while Claudet makes 16 in place of 15 equivalents of hydrogen. That the salt, however, contains but 15 equivalents is clear, from the fact that free nitrogen and hydrogen are found among the products of its decomposition by heat in an atmosphere of carbonic acid gas, which could not be the case upon Claudet's view, since we should then have the equation

$$N_5H_{16}Co_2Cl_3=5NH_3+2CoCl+HCl,$$

while the presence of free nitrogen and hydrogen renders it probable that the decomposition is in reality expressed by the equation

$$5NH_3.Co_2Cl_3=2CoCl+NH_4Cl+3NH_3+N+2H.$$

We have more than once endeavored to determine the amount of gas actually given off during this decomposition, with the view of verifying the equation just given. In every case, however, a portion of the chlorid of cobalt was reduced, either by the free ammonia or by the hydrogen, so that much metallic cobalt was found mixed with the chlorid. A neutral solution of the chlorid of Purpureocobalt is readily decomposed by boiling, a dark-brown precipitate, probably of the hydrated magnetic oxyd, being thrown down, while the solution becomes brown-yellow, and contains chlorid of ammonium and chlorid of Luteocobalt, ammonia being at the same time given off. The quantity of chlorid of Luteocobalt which is thus formed is always very small, being very much less than one equivalent for two equivalents of the chlorid of Purpureocobalt.

On the other hand, a solution of chlorid of Purpureocobalt may be boiled for a very long time with concentrated chlorhydric acid without decomposition, and this stability in the presence of acids is one of the most remarkable peculiarities of the whole class of ammonia-cobalt bases.

Chlorhydric acid and the alkaline chlorids precipitate chlorid of Purpureocobalt from its solutions almost completely, slowly in the cold, but instantly on boiling. Ignited in a current of hydrogen, the salt yields metallic cobalt as a gray spongy mass. Heated in an open crucible, the salt fuses and swells up, giving off abundant vapors of chlorid of ammonium and ammonia, while pure chlorid of cobalt remains in lavender-blue scales. In some cases, however, this is mixed with metallic cobalt, while in others, in which the ignition takes place with free access of air, brilliant iron-black octahedra are formed, which are the anhydrous magnetic oxyd of cobalt, Co_3O_4. The red gas arising from the action of nitric acid upon starch or sawdust exerts a very remarkable influence upon the chlorid of Purpureocobalt, converting it into the nitrate of a base, which will be described further on under the name of Xanthocobalt.

Sulphurous acid solution throws down from solutions of the chlorid a dull orange-brown precipitate, which appears to be a sulphite. By boiling with an excess of the acid this is reduced, and there remains a solution of a protosalt of cobalt.

Sulphuric acid, under certain conditions, converts chlorid of Purpureocobalt into the acid sulphate of the same base.

Zinc may be boiled a long time with an acid solution of the chlorid without producing decomposition or reduction. Formic and oxalic acids have no reducing action. Protochlorid of tin simply unites with the chlorid of Purpureocobalt so as to form a chloro-salt.

The chlorid of Purpureocobalt exhibits a remarkable tendency to unite with metallic chlorids to form chloro-salts. Such compounds are formed with the chlorids of Platinum, Palladium, Mercury, Tin, Zinc, and various other metals. The chlorid of Purpureocobalt even dissolves chlorid of silver in large quantity, doubtless forming with it a double chlorid. It is for this reason, that it is not generally advantageous to prepare the salts of Purpureocobalt by double decomposition between the chlorid and salts of silver.

The reactions of a pure solution of the chlorid of Purpureocobalt are as follows:

Ferrocyanid of potassium gives a yellowish precipitate which quickly becomes chocolate-brown.

Ferridcyanid of potassium gives a beautiful bright orange-red crystalline precipitate.

Cobaltidcyanid of potassium gives a fine red crystalline precipitate.

Oxalate of ammonia gives a beautiful purple-red precipitate of fine needles.

Pyrophosphate of soda gives a lilac precipitate easily soluble in an excess of the precipitant.

Neutral chromate of potash gives a brick-red precipitate.

Bichromate of potash gives orange-yellow scales.

Picrate of ammonia gives a beautiful yellow precipitate.

Terchlorid of gold precipitates the chlorid unchanged.

Bichlorid of platinum gives a fine cinamon-brown precipitate of crystalline scales.

Sulphid of ammonium gives a black precipitate.

Chlorid of mercury gives fine rose-red needles, easily decomposed.

Bichlorid of tin gives pale peachblossom-red silky needles.

Molybdate of ammonia gives a pale peachblossom-red precipitate.

Alkalies and their carbonates give no precipitate.

Iodid and bromid of potassium give no precipitate.

Chlorhydric acid and the alkaline chlorids throw down the chlorid of Purpureocobalt from its solutions as a violet-red powder.

The reactions of the chlorid of Purpureocobalt with the ferridcyanid and cobaltidcyanid of potassium and with oxalate of ammonia are not sufficient to distinguish it from the chlorid of Roseocobalt, which, when pure and freshly prepared, gives also precipitates with these reagents. The character of the precipitates with oxalate of ammonia, bichlorid of platinum, and bichromate of potash enable us, however, readily to distinguish the chlorid of Purpureocobalt from chlorid of Roseocobalt, with which, however, it is not likely to be confounded.

(To be continued.)

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the alloys of Aluminum.*—MM. C. and A. TISSIER have communicated a short note on this subject which is of importance at the present time when the interest in aluminum which had somewhat fallen off is beginning to revive. The authors find that the valuable properties of aluminum are injured by the presence even of small quantities of other metals. One-twentieth of iron or copper make it almost impossible to work the alloy, while one-tenth part of copper renders aluminum as brittle as glass. An alloy of 5 parts of silver with 100 of aluminum works like silver but is harder and takes a finer polish. The one-thousandth of bismuth renders aluminum so brittle that it cracks under the hammer even after being repeatedly annealed. The presence of aluminum in other metals often communicates valuable properties when the quantity is not too large. Thus $\frac{1}{200}$th part of aluminum gives copper a beautiful gold color and hardness enough to scratch the standard alloy of gold employed for coins, whilst at the same time injuring the malleability of the copper. One-tenth of aluminum gives with copper a pale gold-colored alloy of great hardness and malleability, and capable of taking a polish like that of steel. Five parts of aluminum with 100 parts of pure silver give an alloy almost as hard as silver coin containing $\frac{1}{10}$th of copper, and thus permits us to harden silver without introducing a poisonous metal.—*Comptes Rendus*, xliii, 885, *Nov.* 3, 1856.

DEBRAY has also communicated the results of experiments on the alloys of aluminum, apparently more numerous and varied than those of the MM. Tissier. An alloy of aluminum and sodium easily decomposes water, a fact which was the occasion of much loss in the early experiments on the manufacture of aluminum. The aluminum is however easily purified from sodium as well as from iron by a simple fusion with saltpeter. An alloy of 95 parts of iron with 5 of aluminum does not differ essentially in properties from iron. An alloy of 90 parts of copper with 10 of aluminum may be forged by the aid of heat and is not acted on by

sulphydrate of ammonia. It has a fine yellow color but is inferior in lustre to the alloy of 95 copper to 5 of aluminum. An alloy of 97 parts of aluminum and 3 of silver has a very beautiful color, and is not acted on by sulphuretted hydrogen.—*Comptes Rendus*, xliii, 925, *Nov.* 10, 1856.

2. *On the preparation of Lithia.*—Troost has given an easy and simple method of preparing this earth from its ores. When a mixture of lepidolite, carbonate and sulphate of baryta is heated in a good wind furnace the matter fuses and gives at the bottom of the crucible a viscid glass above which an extremely fluid liquid is found which may be poured off while the crucible is hot. If the crucible be allowed to cool, two solid masses are formed, which are easily separated. The upper mass is crystalline and white or slightly rose colored from the presence of manganese. This mass is a combination of the sulphates of baryta, potash, and lithia; by simple washing the alkaline sulphates may be separated from the sulphates of baryta. The same process succeeds with petalite if we add to it such a quantity of sulphate of potash as will make the total quantity of alkali about the same as in lepidolite. By adding more potash to lepidolite itself, the author succeeded in separating still more of the lithia, about 3 per cent. Sulphate and carbonate of lime may be used in place of the salts of barium.—*Comptes Rendus*, xliii, 921.

3. *On Glycol.*—Wurtz has given the name of glycol to a new organic body, obtained from the iodid of elayl, $C_4H_4I_2$, and having the formula $C_4H_6O_4$. When the iodid is mixed with 2 equivalents of dry acetate of silver a violent reaction ensues which yields among other products a neutral fluid which is the acetate of glycol. The reaction is simply $C_4H_4I_2 + 2C_4H_3AgO_4 = C_4H_4O_2, 2C_4H_3O_3 + 2AgI$. The acetate is a limpid liquid, neutral and without odor. It boils at 185° C., and is heavier than water. The acetate has the formula $C_4H_4O_2 \left\{ \begin{matrix} C_4H_3O_3 \\ C_4H_3O_3 \end{matrix} \right.$, the base being biacid. When the acetate is digested with 2 equivalents of fused caustic potash for several hours in an oil-bath at 180° and then distilled at 250°, the glycol passes over as a colorless liquid, which boils at 195° and distills unchanged. Glycol is a limpid oily liquid which has a sweetish taste, and is soluble in all proportions, in water and alcohol. Its formula is $C_4H_6O_4$, and it therefore differs from alcohol in containing 2 eqs. more of oxygen. The author considers it as a true biatomic alcohol, so that we have

Alcohol	$C_4H_6O_2$	uniatomic,
Glycol	$C_4H_6O_4$	biatomic,
Glycerin	$C_6H_8O_6$	triatomic.

While alcohol loses one equivalent of water in forming acetate of ethyl, glycol loses two in forming its corresponding diacetate, and glycerin three in forming its triacetate. In this way is shown, as the author states for the first time in organic chemistry, the principle of inorganic chemistry, that the number of equivalents of an acid which saturates a base is in a simple ratio to the quantity of oxygen in the base.

All salts of silver are decomposed by the iodid of elayl, and in this manner a great number of bodies are obtained which stand midway between the ethers and the fats. Bromid of propylene $C_6H_6Br_2$, acts upon acetate of silver and yields the acetate of propyl-glycol $C_6H_6O_2, 2C_4H_3O_3$,

from which potash separates propyl-glycol $C_6H_8O_4$. Acetal is a mixed ether of glycol, its formula being $C_4H_4O_2, 2C_4H_5O$. The author has also prepared the analogous bodies $C_4H_4O_2 \left\{ \begin{matrix} C_4H_5O \\ C_2H_3O \end{matrix} \right.$ and $C_4H_4O_2 \left\{ \begin{matrix} C_2H_3O \\ C_2H_3O \end{matrix} \right.$; they are etherial liquids which are not decomposed by potash.—*Berichte der Berliner Akad. der Wissen. quoted in Journal für prakt. Chemie*, lxviii, 111.

4. *Action of iodid of phosphorus upon glycerine.*—Berthelot and de Luca have published a memoir upon allyl and its ethers which adds many interesting facts to those already observed by Hofmann and Cahours (see this Journal, vol. xxi, p. 415), and by Zinin. The authors in the first place give a sketch of the properties and formulas of the allyl compounds already known and pass then to the description of the radical itself. Allyl may be prepared by the action of sodium upon iodid of allyl, C_6H_5I. The radical is a volatile liquid having a peculiar penetrating etherial odor analogous to that of horseradish. It boils at 89° C.; its density is 0·684 at 14° C. The density of its vapor is 2·92 = 2 vols. The action of the halogens upon allyl is peculiar. These bodies unite directly with the radical to form compounds containing 2 equivalents of the halogen to one of allyl. Of these the chlorid is liquid while the bromid and iodid are crystalline solids. The authors point out the distinction between iodated propylene, C_6H_5I, and iodid of allyl, $C_6H_5I_2$, which differ in constitution only by one equivalent of iodine and which would be naturally supposed to contain the same radical, being related to each other apparently as a protiodid and deutiodid. This however is not the case, since it is not possible to convert the one into the other. Hence the carburet set free by sodium from iodated propylene does not bear the same relation to the iodid from which it is derived which a radical does to its own iodid. On the other hand sodium regenerates allyl from its bromid and iodid, $C_6H_5Br_2$ and $C_6H_5I_2$. The authors point out the necessity of admitting the existence of three distinct radicals having the formula C_6H_5, which exist in the compounds of propylene, allyl, and glycerine respectively. In like manner allyl-alcohol has the same composition and the same equivalent as acetone and propionic aldehyd, while its chemical and physical properties are very different.—*Ann de Chimie et de Physique*, xlviii, 286, *Nov.*, 1856.

5. *Action of the chlorids and bromids of phosphorus upon glycerine.*—The same chemists have studied the action of the chlorids and bromids of phosphorus upon glycerine. The products in the case of the chlorids of phosphorus have been described by Berthelot. They are monochlorhydrine $C_6H_7ClO_4$, dichlorhydrine $C_6H_6Cl_2O_2$, and epichlorhydrine $C_6H_5ClO_2$. The bromine compounds are analogous, but in addition the authors give various other substances as products of the reaction. Among these are hemibromhydrine $C_{12}H_9BrO_4$, hexaglyceric bromhydrine $C_{36}H_{29}BrO_{14}$, acroleine $C_6H_4O_2$, a phosphorus amid $C_{12}H_9Br_2P$, tribromhydrine $C_6H_5Br_3$, an amid having the formula $C_{12}H_{12}BrNO_4$, and glycerammine $C_6H_9NO_4$. The new base glycerammine is liquid and soluble in water and ether; its platinum salt has the formula $C_6H_9NO_4$, $HCl+PtCl_2$. Glycerammine forms the first instance of an alkaloid formed by a body belonging to the class of sugars.—*Ann. der Chimie et de Physique*, xlviii, 304.

6. *On the formation of urea by the oxydation of albuminous matters.*—BÉCHAMP has succeeded in showing that urea is one of the products of the oxydation of albuminous bodies. The author effects the decomposition by an alkaline solution of hypermanganate of potash. The fibrine of the blood and gluten yield also urea by the same process. From these experiments it is clear that the oxydation of albuminous matters under an alkaline influence yields products very different from those obtained at a higher temperature by means of oxydizing mixtures of peroxyd of manganese or bichromate of potash and sulphuric acid.—*Ann. de Chimie et de Physique*, xlviii, 348.

7. *On triphenylamin.*—GÖSSMANN finds that when oil of cassia is shaken with a concentrated solution of acid sulphite of ammonia, a crystalline mass is produced which when washed with alcohol and distilled with lime gives among other products an oily colorless base, which is triphenylamin. The base changes easily in the air, as do its salts. The platinum salt is a dark yellow flocky precipitate which is soluble in alcohol and crystallizes over sulphuric acid in large chestnut-brown crystals belonging to the regular system. Its formula is $C_{36}H_{16}NCl+PtCl_2$ or $N(C_{12}H_5)_3HCl+PtCl_2$. Iodid of ethyl when heated with the pure base in closed tubes give the iodid of triphenyl-ethyl-ammonium.—*Ann. der Chemie und Pharmacie*, c, 57.

8. *On some products of the oxydation of alcohol.*—DEBUS has discovered among the products of the oxydation of alcohol by nitric acid a new acid which he terms glyoxylic acid, and which has the formula $C_4H_4O_8$ or $C_4H_3O_7+HO$. The acid does not crystallize but forms a thick yellowish syrup. It is easily soluble in water, decomposes the carbonates and saturates the strongest bases.—*Ann. der Chemie und Pharm.*, c, 1–19.

9. *On the quantitative determination of boric acid.*—STROMEYER finds that Berzelius's process for the determination of boric acid in the form of fluoborate of potassium yields accurate results when the boric acid is combined with an alkali, particularly potash, at least one equivalent of potash being present for one of acid. The boric acid is first united with a sufficient quantity of potash, pure fluohydric acid added, and the whole evaporated to dryness, an excess of fluohydric acid being present. The fluoborate separates at first as a jelly which afterward forms small hard crystals. The dry mass is to be stirred with a solution of acetate of potash of 20 per cent, and allowed to stand for some hours, when the supernatant liquid is to be poured upon a weighed filter; this is repeated several times, when the fluoborate is also brought upon the filter and washed with the acetate until the filtrate is no longer precipitated by chlorid of calcium. The acetate is then to be washed out by alcohol of 84 per cent and dried at 100° C. A solution of acetate of potash dissolves chlorid of potassium, nitrate, phosphate, and even, though with difficulty, sulphate of potash. The presence of soda salts should be avoided as the fluorid of sodium is soluble with difficulty. The author obtained however, good results with borax. Other bases must be previously separated. The fluoborate takes up but little space; the filtration must be performed on a funnel of gutta-percha or india-rubber. The evaporation must be performed in vessels of silver or platinum.

10. *On organic compounds containing metals.*—Frankland has discovered two remarkable acids which result from the action of nitric oxyd upon zinc-ethyl and zinc-methyl. Zinc-ethyl slowly absorbs nitric oxyd, forming a crystalline body which inflames in the air. This body is a compound of dinitro-ethylate of zinc and zinc-ethyl. Water decomposes this body, yielding oxyd of zinc, dinitro-ethylate of zinc, and ethyl-hydrogen, the reaction being

$$N_2C_4H_5O_4Zn+ZnC_4H_5+HO=C_4H_5,H+N_2C_4H_5O_4Zn+ZnO.$$

Dinitro-ethylic acid is monobasic and has the formula $N_2C_4H_6O_4$ or $N_2C_4H_5O_3+HO$. The acid exists only in solution and is easily decomposed; its salts are soluble in water and alcohol and do not crystallize easily. A salt of this acid, when heated with concentrated sulphuric acid at 0°, is decomposed, yielding nitrogen, nitrous oxyd, nitric oxyd, and olefiant gas. Zinc-methyl forms precisely analogous compounds. Frankland considers it difficult in the present state of our knowledge to give a satisfactory theory of the constitution of these bodies, but in the mean time refers them to the type of nitrous acid, in which one equivalent of oxygen is replaced by one of an alcohol radical, so that we have

$$N\left\{\begin{matrix}C_nH_{n+1},\\ NO_2,\\ O.\end{matrix}\right.$$

Ann. der Chemie und Pharm., xcix, 333.

[I will here throw out the suggestion that Frankland's new acids may possibly be conjugates of protoxyd of nitrogen. Thus the dinitro-ethylic acid may be $2\overset{\frown}{NO}.C_4H_5O+HO$. This view would satisfactorily explain the decomposition of the salts by sulphuric acid as well as the formation of the acid, which last would be represented by the equation

$$C_4H_5.Zn+2NO_2=2\overset{\frown}{NO}.C_4H_5O+ZnO.$$ W. G.]

11. *Action of sulphuric acid upon the nitriles and amids.*—Buckton and Hofmann have studied the action of sulphuric acid upon the amids and nitriles, setting out from the known fact that strong sulphuric acid converts cyanhydric acid into carbonic oxyd and bisulphate of ammonium. As we have in this case the reaction

$$HC_2N+HO+H_2S_2O_8=2CO+\left.\begin{matrix}H\\ NH_4\end{matrix}\right\}S_2O_8,$$

it might be expected that we should also have the reaction expressed by the equation

$$C_2H_3C_2N+2HO+H_2S_2O_8=2CO+\left.\begin{matrix}H\\ NH_3(C_2H_3)\end{matrix}\right\}S_2O_8.$$

Experiment however did not confirm the expectation but led to the discovery of a new series of sulpho-acids of remarkable character. By the action of sulphuric acid upon acetonitril (cyanid of methyl) or acetamid the authors obtained a new acid, the barium salt of which has the formula $C_2H_2Ba_2S_2O_{12}+4aq$, or $C_2H_2S_2O_{10}+2BaO+4aq$. Buckton and Hofmann call the new acid disulphometholic acid; it is bibasic and forms numerous crystalline salts. The sulphacetic acid of Melsens is also formed during the action of sulphuric acid upon acetonitril and acetamid, and the authors regard the reaction as divided into two phases which may be explained by the following equations:—

$$C_4H_3N+2HO+2H_2S_2O_8=C_4H_4S_2O_{10}+\left.\begin{matrix}H\\NH_4\end{matrix}\right\}S_2O_8,$$

$$C_4H_3N+3H_2S_2O_8\quad=C_2H_4S_4O_{12}+\left.\begin{matrix}H\\NH_4\end{matrix}\right\}S_2O_8+2CO_2.$$

By precisely analogous processes the authors obtained disulphetholic acid $C_4H_4H_2S_4O_{12}$, and sulphopropionic acid $C_6H_4H_2S_2O_{10}$, disulphopropiolic acid $C_6H_6H_2S_2O_{12}$, and sulphobutyric acid $C_8H_6Ba_2S_2O_{10}$, disulphobenzolic acid $C_{12}H_4H_2S_4O_{12}$, and sulphobenzoic acid. The new series of acids may empirically be regarded as compounds of one equivalent of marsh gas and its homologues with five of anhydrous sulphuric acid. By the action of fusing sulphuric acid upon Gerhardt's sulphanilic acid B. and H. obtained a new acid which they term disulphanilic acid, the barium salt of which has the formula $C_{12}H_5Ba_2NS_4O_{12}$ or $C_{12}H_5NS_4O_{10}+2BaO$. In conclusion the authors establish the identity of disulphometholic acid with Liebig's methionic acid obtained by the action of anhydrous sulphuric acid upon ether at a low temperature. Strecker has established the same fact in an independent investigation of methionic acid and its salts.—*Ann. der Chemie und Pharm.*, c, 129 and 199, *Nov.*, 1856.

W. G.

II. MINERALOGY AND GEOLOGY.

1. *Note on the occurrence of Telluret of Silver in California;* by William P. Blake, (Proceedings Acad. Nat. Sci. California).—A specimen obtained from Georgetown, California, resembling a fragment of tarnished lead or silver glance, is found on examination to be chiefly composed of silver and tellurium. The mass is about one inch in length and breadth, and is entirely free from gangue, but incloses native gold, which appears at several points on its surface. An aggregation of cubical crystals, resembling galena, is implanted on one side, and the other is deeply indented with angular cavities probably the prints of quartz crystals. The massive parts of the specimen are sectile and do not show any traces of crystallization; they may be cut with a knife like lead, and give a brilliant metallic surface. Hardness about 2 of Mohs' scale.

In the open tube, before the blowpipe flame, the mineral fuses quietly, coloring the glass a bright yellow under the assay; a white or gray sublimate is deposited at a short distance from, or immediately over it, which, on being heated, fuses into transparent drops resembling oil.

On charcoal, it fuses readily to a leaden-colored globule, which, on cooling, becomes covered with little points or dendrites. This globule flattens under the hammer, but breaks on the edges. With the addition of a little carbonate of soda a globule of silver is readily obtained. A fragment heated to redness in a closed tube or matrass with carbonate of soda and charcoal dust, gives on the addition of a few drops of boiling water the beautiful violet-red or purple solution described by Berzelius as characteristic of tellurium. This solution loses its color after standing for some time, and a dark colored powder is deposited. The mineral dissolved in hot nitric acid with the separation of tellurous acid in crystals.

It is probably the species *Hessite*, but the decision upon this point is reserved until further examinations are made. Its color is darker than the hessite of Savodinsky, Siberia, and it is not quite so hard.

This very rare mineral has not hitherto been observed in America, and its occurrence is therefore of peculiar interest. I am indebted to P. C. Currier, Esq., of Georgetown, for the specimen. It was obtained in that vicinity and probably taken from the auriferous drift, but it can not have been transported far from the original source.

The crystals give reactions for lead and sulphur, and a trace of selenium. They are probably galena but may contain tellurium.

A specimen seen in California in 1854, weighing about two ounces, greatly resembled the massive part of the specimen above described. A small fragment of it which was then obtained also gives the reactions for tellurium and silver. Its precise locality is unknown.

It is probable that tellurium combined with silver, lead, or bismuth will be found in the auriferous quartz of Grass Valley and other localities. A few specimens in my possession contain small brilliant grains resembling tetradymite, but their exact character is not yet determined.

2. *Notices of Remains of Extinct Vertebrated Animals discovered by Professor E. Emmons;* by JOSEPH LEIDY, M. D., (Proc. Acad. Nat. Sci. Philad., viii, 255).—CETACEA. (1.) *Orycterocetus cornutidens*, Leidy (*O. quadratidens*, Proc. A. N. S., vii, 378).—The genus was originally proposed on several long horn-like teeth, together with fragments of jaws found in the miocene deposit of Virginia. Prof. Emmons has also discovered a tooth, apparently of the same species, in the miocene deposit of North Carolina. The tooth bears a wonderful resemblance to the horn of a young ox. It is nearly 5 inches long in the curve and over an inch in diameter at base, which is hollowed into a deep conical cavity, as in the spermaceti whale.

(2.) *Drepanodon impar*, Leidy.—This species is founded on the crown of a tooth discovered by Prof. Emmons in the miocene deposit of Cape Fear, North Carolina. The specimen, in form, bears a strong resemblance to the crown of the inferior canine tooth of a bear, but it has only one trenchant ridge, and this is situated postero-internally. The enamel is thin and smooth; the base of the crown is hollowed conically. Length of specimen 10 lines; breadth at base antero-posteriorly 7 lines, transversely 5 lines.

(3.) *Pliogonodon priscus*, Leidy.—Founded on two much mutilated specimens, consisting of the crowns of teeth, discovered by Prof. Emmons in a miocene deposit of Cape Fear, in North Carolina. Teeth elongated conical, nearly straight or only slightly curved inwardly, in section circular, with a pair of opposed carinæ on the inner side; surfaces divided into numerous narrow planes, with a few vertical interrupted plicæ, which are more numerous on the inner side. Enamel finely wrinkled; and the dentine concentric. Base of crown hollowed. Probable length of crown when perfect 2 inches, breadth of the base $\frac{3}{4}$ of an inch. The teeth differ from those of *Mosasaurus* in their narrower proportion, straightness, circular section, and plicæ of enamel; from those of *Polyptychodon* in the possession of divisional planes and opposed carinæ; and from those of *Pleiosaurus* in the former character and the circular section.

(4.) *Palæosaurus?* (*Compsosaurus*) *priscus*, Leidy, ante p. 165.—Half a dozen isolated teeth of this saurian are contained in the collection of Prof. Emmons.

(5.) *Omosaurus perplexus*, Leidy.—An Enaliosaurian, based upon a number of teeth of varied character, vertebræ, fragments of ribs and other bones, and the impression of a dermal plate, obtained from the coal-field [mesozoic] of Chatham Co., North Carolina, by Prof. Emmons and also by Prof. M. Tuomey. Teeth elongated conical, pointed, nearly straight, or more or less moderately curved inwardly, with opposed carinæ on the inner side, which are entire or denticulated; transverse section subcircular, flattened internally; surfaces even, or more or less distinctly fluted on the outer side or all around, and covered with minute interrupted ridges, which are vertical on the even surface, oblique on the fluted surface, and divergent downward in the vicinity of the carinæ. Crown solid, enamel thin, dentine concentric; fang subcylindrical, hollowed at base. Length from 5 lines to 1¾ inches, breadth from 2 lines to 4¾ lines. Bodies of the vertebræ bi-concave and much constricted, as in *Palæosaurus?* and *Clepsysaurus*. Length of one of the posterior cervical bodies 16 lines, depth of its articular surfaces 17 lines, width 15 lines. Dermal plate covered with radiating, bifurcating and anastomosing ridges. Allied to *Clepsysaurus* and *Centemodon*, Lea, and probably identical with them.

Labyrinthodonta. (6.) *Dictyocephalus elegans*, Leidy.—Founded on the upper portion of a cranium discovered by Prof. Emmons in the coal-field of Chatham Co., N. C. Plates of the cranium covered with reticular ridges in a general radiant manner. Parietals comparatively short, broader in front than behind; parietal foramen near the centre of the bones. Occipitals quadrate, a little longer than broad. Posterior outline of the cranium with a superficial transverse concavity on each side and not a deep sinus as in *Trematosaurus* and *Archegosaurus*. Breadth of occipital outline 28 lines; length of parietals 8½ lines, breadth anteriorly 3¾ lines, posteriorly 3 lines. Probable length of head, considering it to have had nearly the proportions of *Trematosaurus*, 4 inches, breadth 2¼ inches.

Pisces. (7.) *Ischyrhiza antiqua*, Leidy.—The genus was originally based on a tooth found in the Greensand of New Jersey. Two teeth apparently of a second species have been obtained by Prof. Emmons on the Neuse River, N. C. Crown of the teeth, when perfect, apparently, laterally compressed conical. Fang robust, quadrately pyramidal, curved; with a rugged base which is bifurcated antero-posteriorly and more deeply before than behind. Pulp cavity entirely closed at bottom. Probable length of specimens when entire 1½, and 2 inches; length of fang 10 lines, and 1 inch; breadth of crown at base antero-posteriorly 5 lines, 6 lines; laterally 3¾ l., 4¾ l.; breadth of fang at bottom antero-posteriorly 7 l., 8½ l.; laterally 6½ l., 7 l.

3. *Report of the Geological Survey in Kentucky, made during the years* 1854 *and* 1855; by David Dale Owen, Principal Geologist, assisted by Robert Peter, Chemical Assistant, Sidney S. Lyon, Topographical Assistant. 416 pp., large 8vo, with plates, maps and sections. Frankfort, Kentucky.—This fine and large volume is new evidence that the people of the land appreciate the importance of searching into the rocks for their mineral wealth, and studying the strata also for their scientific developments. Geological surveys have been carried on in nearly all the states of the Union, and although much remains to be done, we

are beginning to know the country we inhabit, and develop its abundant resources. Kentucky is now adding her part to the rock-map of the continent, and we trust the work over that large state will be carried on until its geology is thoroughly understood. Her coal and iron beds are inducements enough for extended research, if these were the only results to be looked for. Already the Breckinridge coal region is becoming the seat of a new manufacture for the county, the distillation undertaken, on a large scale, yielding benzole, lubricating oil, paraffine, and other valuable products.

This volume presents the results of nearly two years exploration. It gives a general sketch of the rocks as far as now explored, with details of portions brought under special examination. The formations recognized in the state are briefly mentioned as follows:—

"(1.) Superficial Deposits or Quaternary loam, marl, clays, and gravel, belonging to the age of the Mammoth, Mastodon, and Megalonyx, or Pleistocene formation.

This includes all those fine deposits of comparatively recent date, which appear to have settled in wide expansions of our great rivers, just previous to the time when they contracted into their present channels, together with the associated gravel beds.

(2.) The Coal Measures: embracing the sandstones, shales, ironstones, millstone grit, and conglomerate, together with the limestones associated with the *workable* beds of coal.

(3.) Subcarboniferous Limestone, chert and fine grained sandstones, being the strata on which the coal measures repose, and extending down to the

(4.) Black Lingula Shales: i. e., all the dark argillaceous beds on which the Subcarboniferous sandstones and limestones of the Knobby Regions rest, near the mouth of Salt river, the head of Green river, and that part of the Cumberland situated between its Narrows and the Turkey Neck Bend, belonging to the Devonian Era.

(5.) Grey Coralline Falls Limestones, including the limestones under the black shales which form the falls of the Ohio, down to the chain coral or *Catenipora* limestone, and which are referable to the Devonian Epoch.

(6.) The Chain coral and Upper Magnesian Cliff Limestones, such as occur on Beargrass and elsewhere in Jefferson county.

(7.) The Blue, Shell and Birdseye Limestones of Fayette and Franklin counties, and throughout most of the so-called Blue-grass counties of Middle and Northern Kentucky.

As yet no formations of more ancient date than this latter have been discovered; hence, all its formations, so far as at present known, belong to the sedimentary and fossiliferous series, of purely aqueous origin, and, with the exception of the Lacustrine loams, marls, and subordinate gravel beds, all have been formed beneath the bed of an ocean."

Among the facts under the first of these divisions, a description is given of the bone deposit on Canoe Creek, a tributary of the Ohio, five to six miles below Henderson. The bones belong to the *Megalonyx Jeffersonii*. They were found 70 feet below the ancient channel of Canoe Creek, and 5 or 6 feet above the ordinary low stage of water. With them occur, in the ferruginous sand, shells of *Paludina ponderosa*, *Melania canaliculata*,

Cyclas rivularis, *Physa heterostropha*, *Lymnæa elongata*, *Planorbis bicarinata*, *P. lens*, *Valvata tricarinata* (all of *Say*), along with fragments of Unios, and stems and limbs of trees. The specimens of Megalonyx bones are described in the Smithsonian Contributions by Dr. Leidy. Lignite or brown coal is not uncommon in the Quaternary deposits.

The extent and general features of the Coal Measures are thus described:—p. 29.

"A very large area of Kentucky is occupied by this, the most important of geological formations, in a practical point of view. There is, indeed, no State in the Union, except Kentucky, whose territory extends over a large area of *two* coal fields.

In southwestern Kentucky the whole of eight counties and a part of four other counties are embraced in the Middle coal field of the Mississippi valley, or the coal field which lies partly in Illinois, partly in Indiana, and partly in Kentucky. In Eastern Kentucky fifteen counties, and a large area of five more counties, are included in the great Appalachian coal field, i. e., in the coal region occupying the western slopes of the Alleghany mountains and the Cumberland range, situated partly in Pennsylvania, Virginia, Ohio, Tennessee, and these above mentioned eastern counties of Kentucky.

Of the hundred and three counties of this State, more than twenty-six counties may be considered as situated upon the Coal Measures—or over one quarter of the whole area of the State.

The geological formations of the southwestern coal field of Kentucky are better understood, at present, than its eastern coal field, lying more remote from the Ohio river. I have spent, however, several months last summer in a reconnoissance of a considerable portion of the eastern coal field, and am able now to furnish important information in regard to its extent, resources, and the qualities of some of the principal beds.

The approximate boundaries of the southern coal field, situated in Kentucky, are as follows: commencing on the Ohio river at the mouth of Tradewater, it runs up the valley of that stream, whose course very nearly coincides with its southwestern limits. From near the sources of Tradewater, in the northern part of Christian county, its southern boundary runs by the head-waters of Pond river, near the lines dividing Muhlenberg, Todd, Logan, and Butler counties, crossing Muddy river near its forks; thence through the southern part of Butler county, crossing Barren river between the mouth of Gasper river and the junction of Barren river and Green river; thence east along the divide between those rivers, through Warren and Edmonson counties, to near the mouth of Nolin creek; thence nearly north to the mouth of Dismal. Either an outlier or tongue of the coal measures appears to stretch away to the east, to the confines of Grayson and Hart counties, and even on to the waters of Roundstone; but the main boundary takes from Dismal creek a northwesterly course south of Grayson Springs, near the sources of Clay Lick and Caney creeks, towards the Falls of Rough creek; thence north by the sources of Panther creek, nearly along the line dividing Hancock and Breckinridge counties, until it strikes the Ohio river again at the Great South Bend, near the limits of the above counties.

Such are the general boundaries of this coal field, as far as at present ascertained. All the territory included between this line and the Ohio

river may be regarded as belonging to the coal formation, but the line cannot be defined in all its meanders until the detailed survey shall have been carried through Hopkins, Muhlenburg, Christian, Todd, Butler, Warren, Edmonson, Grayson, Hart, Breckinridge, and Hancock, and their topography plotted accurately, as has been accomplished of Union and part of Crittenden counties.

The coal beds included in these counties naturally divide themselves into Upper and Lower Coal Measures. These are separated from each other not only by a prominent sandstone formation, but they have been cast off from continuity, immediately on the Ohio river, by an extensive uplift and dislocation of the geological formation which stretches from Gold Hill, on the Illinois side of the Ohio river, across the bed of that stream, at Shawneetown, to Bald Hill, in Union county.

The Topographical Assistant, in his detailed survey of Union county, has traced a continuation of this upheaval in a nearly east and west course through the entire county. Beyond the Valley of Cypress this disturbed belt has an increased width to the boundary of Henderson county. Beyond this point it has not yet been systematically followed; but the occurrence of disturbances, with a reversal of dip, near the confluence of Pond and Green rivers, render it probable that it can be traced completely through the coal field.

In Kentucky there is no evidence whatever that this disturbance occurred prior to the deposition of the coal measures; on the contrary it has implicated in its movements not only the Subcarboniferous limestone and Millstone grit, but also the entire coal formation, which lies in conformable dip on either side of the axis. In the northeast edge of Union county, and in the bed of the Ohio river, the tilted strata, lying immediately in the line of greatest disturbance, are cast up on edge and lie in great confusion—especially where the strata seem to have partially sunk back into the chasm—and thus been much fractured, crushed, and thrown out of place, so as to convey, to limited observation, the appearance of unconformability; but it can be conclusively shown that the coal measures north and south of this disturbance were deposited in one and the same basin. For a limited space along the Ohio river, the Shawneetown fault has rent asunder the coal measures, and thrown off the upper coal measures to the north, and the lower coal measures to the south; but in the interior of Union county the upper coal measures occur on both sides of the disturbance, and, though their continuity is broken for a certain distance, the perfect identity of some of the beds on both sides of the disturbance is clearly apparent. North of this disturbance the upper coal measures prevail as high up the river as its south bend, in Davies county; south of this disturbance, down to the mouth of Tradewater, the coal measures extend even to the elevated ridges of Duffis' creek."

The upper coal measures comprise at least eight workable beds of coal, in a thickness of nearly 2000 feet.

The rock separating the upper and lower coal measures has been called the *Anvil Rock*, a name originating from the accidental form of two masses in Union county, southwestern Kentucky. The thickness of the beds of the lower are over 900 feet, and they contain ten workable beds of coal, one of them about five feet thick and the others one to three feet. Average specific gravity of the coal 1·284, giving very

nearly eighty lbs. to the cubic foot. The coal of the five foot seam gave for its specific gravity 1·308, and for the total volatile matter 39·5 per cent with five per cent of light gray ashes.

The Coal Measures afford numerous beds of iron ores. In the upper 400 feet of the strata of the southwestern coal field, there are from four to six different beds of limestone; one, the Carthage limestone, cropping out on the Ohio river, a mile below Uniontown, is eight feet thick, and two others have about the same thickness. The lower 900 feet of the coal measures afford only two limestone beds worthy of note, immediately on the Ohio river; one over the first coal under the Anvil Rock (observed in Illinois but not yet in Kentucky), and one about four feet thick, lying under the sixth bed of coal above the Anvil Rock called the Curlew coal. The lower southern Coal Measures are richer in limestones than their southwestern equivalents. A seven-foot coal bed in Hopkins and Muhlenberg counties has generally a heavy dark bituminous limestone two or three feet thick overlying it. At Greenville there is a brecciated layer seven or eight feet thick.

Almost all the beds of coal rest on a bed of fire-clay, and these underclays very generally afford remains of *Stigmaria ficoides*.

The *Black Lingula shale* which underlies the Subcarboniferous rock is a little over 100 feet thick at the Falls of the Ohio, where it is in sight. To the north it gradually thins out.

The Report, besides chapters also on the Devonian and Silurian rocks, contains a long and valuable chemical report by Dr. Robert Peter, giving the results of 169 analyses of iron ores, coals, limestones, soils, etc., with important observations on these materials. It also treats of some mineral waters. The volume closes with a Topographical Geological Report of that portion of Kentucky including Union and part of Crittenden counties, surveyed in 1854 and 1855 by Sidney S. Lyon, Topographical Assistant, illustrated by a large map.

4. *On a Shower of Ashes over the plains of Quito;* by Rev. George Jones, U. S. N. (From a letter to Prof. Silliman, dated Quito, Ecuador, Dec. 13, 1856.)—*Non cuivis homini contingit adire Corinthum*—said Horace; and I suppose the same fact respecting Quito will help to give an interest to a letter from an old friend at this place. The interest to you will be increased when I tell you that I write in the midst of what looks like one of our snow-storms at home, the important difference being that our skies are dropping upon us *ashes* instead of snow. Yesterday morning we noticed that at the south the sky had an unusual appearance, being of a purple color for about 90° along the horizon and so up to about 45° in height, the edge of this being mixed up with patches of white. About 12 o'clock ashes began to fall; first in small quantities, but, by 8 o'clock, the fall had got to be so considerable as to powder the clothes quickly, on our going out; and people coming into a house would look as we do at home when coming in from a snow-storm.

We all presumed that this must come from Cotopaxi, which is about thirty miles from us in a South by East direction, and has been in a greater or less state of activity for about a year. We had, here, a fall of ashes about a month ago, but that was so slight as scarcely to be perceptible. The ashes then were black and coarser than in the present case: I send you a specimen of these which are falling now. I have just taken a care-

ful measurement, and find that the depth, on a level, is one-quarter of an inch. This may not appear to be a great deal; but when we consider our distance from Cotopaxi, and that the whole country is covered over to that depth, the aggregate will be seen to be considerable. The fall of ashes is now not so great, but they are still coming down, looking in the air like a thin mist or a light snow-storm. The country has a most singular and melancholy appearance. The ashes are heavy and the trees are bowed under their loads, while every where, in the streets and on the hill sides, there is the same ashy color, to which the sun, scarcely seen, gives only an additional sickly hue. Last night, although the moon was but one day past being full, was the darkest night that I think I have ever seen. [The ashes appear under a lens to be feldspar grains.]

There has been considerable uneasiness and anxiety in this place, probably through fear of convulsions in Cotopaxi that may reach to Quito; while indeed the sufferings to cattle must now be considerable, as all the grass has on it this thick coating of ashes. The bells of the city have been tolling through alarm almost constantly since 8 o'clock last evening; services have been held in the churches; and late in the night there was a procession of citizens in double rank, with candles and lanterns; the procession was more than a quarter of a mile in length, and made the round of the churches, having a service in each, as it passed through. The people chanted as they passed along the streets; they were enveloped in shawls and ponchos to protect them from the falling ashes; and their dim, ghostlike appearance, their sad chant, *Ora pro nobis, Ora pro nobis*, with the haze about their candles, the ashy appearance of the sky so far as illumined by the lights, the blackness above, and the solemn tolling of the bells all over the city, had a most melancholy effect. They carried, in the procession, three images of a peculiarly sacred character, brought from Rome.

We have not yet heard from places nearer Cotopaxi, but are expecting sad accounts both from the ashen shower and from the melting of the snows on that mountain and the consequent overflowings of the rivers in its neighborhood. There is a city of some size, Latacunga—(where Cassola's college is situated) not far from Cotopaxi; which city has in several instances been a very severe sufferer in the convulsions originating in the volcano.

1 o'clock.—The fall of ashes has recommenced as thick as ever and the bells are tolling again. Another procession has just passed the door. It was a very sad and solemn spectacle. The people were seven deep on each side of the street, the inmost line with candles and lanterns; the women with rebosos and shawls over their heads, the men bare-headed, their heads and garments all covered with ashes. They had several images on platforms; and bands of music playing mournful tunes; sometimes chanting.

7 P. M.—The ash-shower has ceased; but Cotopaxi is thundering at a prodigious rate.

Monday evening, 15th.—It is now pretty well ascertained that the ashes were not from Cotopaxi, but from a volcano called Laraurco, in a wild country to the eastward of this, a considerable distance. There was a similar shower of ashes from that volcano in 1844, about as heavy as this,

but on that occasion the air was more obscured than at this time, so much so that people had to use lanterns along the streets in Quito, at midday.

Wednesday.—Still doubts about the origin of the ashes; more probably they are from Cotopaxi.

5. *Palæotrochis* of Emmons.—This supposed fossil coral, described by Prof. Emmons in volume xxii, p. 389 of this Journal, is regarded by Prof. James Hall, after an examination of many specimens, as nothing but concretions in quartz rock.

III. BOTANY AND ZOOLOGY.

1. *Origin of the Embryo in Plants.—The Development of the Ovule of Santalum album; with some Remarks on the Phenomena of Impregnation in Plants generally;* by ARTHUR HENFREY, F.R.S., etc.—This is a paper in the *Linnæan Transactions*, vol. xxii, and was read before the Linnæan Society of London a year ago, before the publication of Dr. Radlkofer's memoir, which we gave some account of in the November number of this Journal. The results of these two contributions to embryology nearly correspond in their main features, although expressed in a somewhat different way; and they close a long and lively controversy, giving *coup de grace* to the "theory of the pollinists," as we have already stated.* In Santalum, Prof. Henfrey finds the germinal vesicle, or primordial cell of the embryo, to exist antecedent to impregnation, i. e. before the arrival of the pollen-tube; that the latter, (contrary to what Griffith supposed) does not penetrate the embryo-sac, but becomes firmly adherent to its surface; that the germinal vesicle within is at some distance from the wall of the embryo-sac; and that, between the two a pair of corpuscles or "coagula" are interposed, placed side by side, with a narrow space between. He thinks it probable that the walls at the point of adhesion of the pollen-tube and the embryo-sac are absorbed, and that the pollen-tube thus discharges its contents into the embryo-sac, which contents reach the embryonal nucleus and determine its conversion into a cell; he therefore looks upon the process as analogous to conjugation in the lower Algæ,—a process which, by the way, we have always wondered that Mohl should deny to belong to sexual reproduction. Of this direct communication, however, Prof. Henfrey has no proof to offer; and in fact this is just the problem for embryologists to resolve, viz, how does the pollen act, to determine the conversion of a *protoplasmic nucleus* into the initial embryo? Prof. Henfrey, in this paper, as he had announced in anticipation of its publication, regards what has been called the embryonal vesicle as merely a soft nucleus of protoplasm, which acquires a cellulose coat, and so becomes a real cell, only as the result of impregnation, and after the adhesion of the pollen-tube with the embryo-sac. The closing paragraph of the memoir, which is dated Jan. 30, 1856, embodies the view to which he had then arrived. "In my memoir on Orchis Morio, I described the

* A French translation of Radlkofer's memoir is given in *Ann. Sci. Nat.*, tom. v, No. 4, 1856. His results are essentially those of Tulasne, completed by a demonstration of the existence of the embryonal vesicle antecedent to impregnation, or rather of the existence of a pair of embryonal vesicles, adherent to the summit of the embryo-sac, of which the one generally contiguous to the extremity of the pollen-tube without becomes abortive, while the other developes into the suspensor of the embryo.

nascent germinal vesicles as cells. Hofmeister and others in like manner call them cells; but comparison of my older drawings and those of Hofmeister with new observations, *leads me to believe* that, on careful examination, these bodies will be found to consist of nuclei or 'protoplasts' before fertilization. I may note in reference to this, that I have already some confirmation from another case besides Santalum, and I trust to bring forward hereafter more complete evidence on the subject." A. G.

2. *Botanical Necrology for* 1856.—The more distinguished botanists who have deceased during the past year, are the following:

Dr. Wikström, Professor of Botany at Stockholm, author of several botanical works of merit, and of a series of Annual Reports on the Progress of Botany, published by the Academy of Sciences of Stockholm. He had reached the age of 67 years.

Dr. von Steudel, of Esslingen, in Wurtemburg, author of the well known *Nomenclator Botanicus*, and of the *Synopsis Plantarum Glumacearum*, noticed in a recent volume of this Journal.

George Don, of London, a brother of the more distinguished David Don, who died several years ago, and author of the Synopsis of Dichlamydeous Plants published several years ago, in 4 heavy 4to volumes, under the title of a *General System of Gardening and Botany*.

Prof. Bojer of Mauritius, aged 56. An interesting biographical notice of him is published in Hooker's Journal of Botany for October last.

Dr. Dozy, of Leyden, the distinguished Bryologist, has followed within a year his associate, Dr. Molkenboer. The admirable muscological works published conjointly by these two botanists have been noticed in this Journal. The *Bryologia Javanica*, which Dr. Dozy was continuing unaided since the death of his lamented associate, was one of the most elaborate and best works of the age in this department of science, after the *Bryologia Europœa*. Although it will hardly be possible to supply Dr. Dozy's place in this work, yet we learn that endeavors will be made to carry it on to a completion, making use of a good deal of unpublished materials left by Dr. Dozy.

Dr. Liebmann, Professor of Botany and Director of the Botanic Garden at Copenhagen, after a long illness, died on the 29th of October last, at the early age of 43 years. This excellent botanist and most interesting man had travelled largely in Mexico, and made vast collections of plants, upon which he had published several memoirs. He had, we believe, completed his splendid *Monograph of Mexican Oaks*, in folio, with 40 plates,—a work for which he had accumulated all the available materials now in Europe, and which will have a particular interest for us, on account of our numerous related Oaks of New Mexico and California. Dr. Liebmann's death is a great loss to science, and will be sincerely mourned, even in this country, by those to whom his amiable and excellent qualities had greatly endeared him.

Prof. Dunal, of Montpelier, one of the earliest pupils and most attached friends of the late DeCandolle, the elaborator of the *Solanaceæ* for the Prodromus, and author of several important monographs, is referred to by the French correspondent of this Journal (in the January number), as recently deceased. We have not yet received any notice of this event through the botanical journals or private correspondence. A. G.

3. *Gray's First Lessons in Botany and Vegetable Physiology, illustrated by over 360 wood-engravings from original drawings by Isaac Sprague, to which is added a copious Glossary or Dictionary of Botanical Terms*, a volume of about 250 pages,—intended for schools and classes generally, and as an Introduction to the *Manual of the Botany of the Northern United States*,—is just published by G. P. Putnam & Co. and Ivison & Phinney, New York.

The same publishers have issued a School and College edition of the *Manual of the Botany of the Northern United States*, with six plates, at a greatly reduced price.

4. *On the Causes of the Opening and Closing of Stomates;* by Hugo von Mohl, (Botanische Zeitung, 1856, No. 40, p. 697, et seqq.)—In this memoir von Mohl corroborates by actual experiments the general impression, the truth of which had not been demonstrated, that stomates shut when the guardian cells collapse, and open when they become turgid.

The opening of the stomate is guarded by two crescent-shaped cells, the guardian-cells, which generally take the following form. On their external surface each bears a cuticular projection which is usually formed by a thin membrane; in other cases however it consists of the cell-wall considerably thickened, or the cell-wall is sometimes even thick enough to form a salient protuberance. The edges of these projections unite at both the ends of the stomate, so as to make an orifice above the true opening of the stomate; this orifice may be wider or narrower than the true opening. It leads into a continuation of the true opening, filled with air and lying above the opening; this von Mohl calls the anterior cavity, or ante-chamber, (Vorhof), and the opening, the orifice of the ante-chamber. It is bounded on both of its lower sides by the upper part of the lateral surfaces of the guardian-cells, these surfaces being concave horizontally and convex vertically. Turned towards the stomatic cavity, on the lower side of the guardian-cells, there lies in most plants another projection like that on the upper side, but generally smaller, by which a posterior cavity corresponding to the anterior cavity, is separated from the cavity of the stomate.

A transverse section usually shows that the thickness of the walls of the guardian-cells is very unequal in different places; the part of the wall contiguous to the epidermal cells is generally rather thin, so that these cells must prevent the guardian-cells from swelling out at this part.

Having cut through the epidermal cells, so as to discharge their contents and thus prevent them from exerting any lateral pressure on the guardian cells, it was found that when placed in *water* (which they imbibe) the guardian cells increased the space between them very perceptibly; but when placed in a *solution of sugar*, (into which they exude a portion of their contents) they closed it completely. By changing from water to a solution of sugar, the same opening might be alternately opened and closed. Another series of experiments on *intact* leaves showed that this action of the guardian cells is impeded by the pressure of the epidermal cells in proportion as they come into contact with the former. This is also shown by the fact that when this pressure is taken off by emptying the epidermal cells of their contents (which may be done by immersing the latter in a solution of sugar) the guardian-cells always open. As the epidermal cells contain more sap than the guardian-cells the same result is obtained by letting a leaf wither off. The orifices of intact leaves cut

off in the morning were found to be closed; when exposed to the sun for several hours they opened again, but closed with rapidity when immersed in water; showing that the power of the guardian-cells is increased, in comparison with that of the epidermal cells, by the influence of light and heat quite independently of the humid state in which they may occur. This, the author thinks, can hardly be explained except by assuming that when the guardian-cells are exposed to the influence of these agents they form such combinations as are able to induce a powerful endosmosis, and are more or less decomposed when light is withdrawn; for, as is well known, the guardian-cells, like the cells of the parenchyma, contain chlorophyllaceous matter.

Direct comparative measurements show that the projecting part of the guardian-cells, beyond the anterior cavity, contracts but slightly, so that the process is effected chiefly by the change in the form of the boundaries of the true opening.

The guardian cells expand most in a vertical direction, and thus change their transverse diameter from a circular to an elliptical form, so as to draw in the thinner portion of the lateral surface which lies free in the opening of the stomate. This explains why the opening is not closed when these cells are distended by the water which fills them.

C. F. Stone.

5. *On a boring Sponge;* by J. Leidy, (Proc. Acad. Nat. Sci., Philad., viii, 162.)—Dr. Leidy also directed the attention of the members to several shells of the oyster and clam (*Ostrea virginiana* and *Venus mercenaria*) much perforated, which are common on the ocean shore, where they are noticed by all visitors. Dr. L. had for a long time suspected that the perforations were due to some other molluscous animal or a worm; and he had frequently sought for them. The last summer, in dredging, in company with Mr. Ashmead and Prof. Baird, on an old oyster bed, at Great Egg Harbor, New Jersey, a large number of these perforated shells were obtained, and all of them were observed to be occupied by a sulphur yellow sponge of the genus *Cliona*. This boring sponge forms an extensive system of galleries between the outer and inner layer of the shells, and protrudes through the perforations of the latter tubular processes, from one to two lines long and one-half to three-fourths of a line wide. The tubes are of two kinds; the most numerous being cylindrical and expanded at the orifice in a corolla form, with their margin thin, translucent, entire, veined with more opaque lines, and with the throat bristling with silicious spiculæ. The second kind of tubes are comparatively few, about as one is to thirty of the other, and are shorter, wider, not expanded at the orifice, and the throat unobstructed with spiculæ. Some of the second variety of tubes are constituted of a confluent pair, the throat of which bifurcates at bottom. Both kinds of the tubes are very slightly contractile, and under irritation may gradually assume the appearance of superficial wart-like eminences within the perforations of the shell occupied by the sponge. Water obtains access to the interior of the latter through the more numerous tubes, and is expelled in quite active currents from the wider tubes.

In structure the sponge is composed of an intertexture of granular matter and pin-like silicious spiculæ. Several species of *Cliona* are indicated by European naturalists, but are not characterized with sufficient detail to determine whether the one above indicated is distinct or not from them.

Dr. L. further added, it might appear only of scientific interest to observe a structure so low as the sponge is classified in the organic kingdom, endowed with the power of penetrating such dense and hard bodies as the shell of the clam and oyster, but he suspected that the agency of the boring sponge was a highly important one in the sequence of natural phenomena, as it is a means by which dead shells are rapidly decomposed to be dissolved in the ocean water, where they may again serve as the elements of construction of the habitations of the rising generations of molluscous animals. In confirmation of this view Dr. L. stated, that an extensive bed of oysters, which had been planted by Mr. Thomas Beasley, at Great Egg Harbor, and which was in excellent condition three years since, had been subsequently destroyed by an accumulation of mud. The shells of the dead oysters, which were of large size and in great number, in the course of two years have been so completely riddled by the boring Cliona that they may be crushed with the utmost ease, whereas without the agency of this sponge the dead shells might have remained in their soft, muddy bed, devoid of sand and pebbles, undecomposed perhaps even for a century.

6. *Appendix to a paper on Reptiles in the Collection of the Academy of Natural Sciences of Philadelphia;* by E. Hallowell, (Proc. Acad. N. S. Phil., viii, 236.)—The Reptiles of Jamaica appear for the most part to be specifically distinct from those of Cuba. The following is a comparative list of those enumerated by Duméril and Bibron, Mr. Gray, Mr. Gosse, and others, including those described or mentioned in this paper. To these I have added a list of the reptiles of Martinique, for the habitat of which I am indebted to Duméril and Bibron.

Cuba.	*Jamaica.*	*Martinique.*
CHELONIA.	CHELONIA.	CHELONIA.
Cheloniadæ.	Cheloniadæ.	Chelonidæ.
Chelonia mydas.	Sphargis coriacea.	
Chelonia virgata.		
Chelonia cuouana.		
Testudinidæ.	Testudinidæ.	Testudinidæ.
	Testudo carbonaria ?	
Emydidæ.	Emydidæ.	Emydidæ.
Emys decussata.	Emys decussata.	
Emys rugosa.		
SAURIA.	SAURIA.	SAURIA.
Crocodilidæ.	Crocodilidæ.	
Crocodilus acutus.	Crocodilus acutus.	
Crocodilus rhombifer.		
Geckotidæ.	Geckotidæ.	Geckotidæ.
Hemidactylus mabouia.	Hemidactylus stenodactylus.	Hemidactylus mabouia.
Sphæriodactylus sputator.	Sphæriodactylus sputator.	Sphæriodactylus sputator.
Sphæriodactylus cinereus.	Sphæriodactylus punctatissimus.	Sphæriodactylus punctatissimus.
	Sphæriodactylus Argus, G.	Sphæriodactylus fantasticus.
Gymnodactylus albogularis.	Sphæriodactylus oxyrhinus, G.	Gymnodactylus albogularis.
	Platydactylus theconyx.	Platydactylus theconyx.

Cuba.	*Jamaica.*	*Martinique.*
IGUANIDÆ.	IGUANIDÆ.	IGUANIDÆ.
Cyclura Harlani.	Anolis Edwardsii.	Anolis Alligator.
Anolis equestris.	Anolis punctatissimus, H.	Anolis marmoratus.
Anolis Sagræi.	Anolis Sagræi.	Anolis cristatellus.
Anolis vermiculatus.	Anolis iodurus, G.	Anolis vermiculatus.
Anolis Carolinensis.	Anolis opalinus, G.	Anolis lineatus.
Anolis lucius.	Placopsis ocellata, G.	Anolis pulchellus.
Anolis angusticeps, H.	Cyclura Collei.	Anolis chloro-cyanus.
Anolis heterolepis, H.	Cyclura lophoma.	Basilicus mitratus.
Anolis (Acantholis) Loysiana.		Iguana tuberculatus.
Anolis chamæleonides (Chamæleolis Fernandina).		Iguana nudicollis.
Holotropis microlophus.		Holotropis Herminieri.
Holotropis vittatus.		Tropidolepis (Sceloporus) undulatus?
LACERTIDÆ.	LACERTIDÆ.	LACERTIDÆ.
Ameiva Auberi.	Ameiva Sloanei.	Ameiva Pleii.
		Cnemidophorus lemniscatus.
		Cnemidophorus sexlineatus.
CHALCIDIDÆ.		CHALCIDIDÆ.
Amphisbæna punctata.		Amphistæna cœca.
SCINCIDÆ.	SCINCIDÆ.	SCINCIDÆ.
Diploglossus Sagræi.	Eumeces Sloanei.	Eumeces mabouia.
	Diploglossus Shâwii.	Diploglossus Pleii.
		Gymnopthalmus quadrilineatus.
OPHIDIA.	OPHIDIA.	OPHIDIA.
BOIDÆ.	BOIDÆ.	BOIDÆ.
Tropidurus melanurus.	Chilabothrus inornatus.	Epicrates Conchris.
Leionotus maculatus.	Leinotus maculatus.	
Epicrates anguliferus.		
Notophis bicarinatus.		
	LEPTOGNATHIDÆ.	
	Ischognathus DeKayi.	
		OXYCEPHALIDÆ.
		Oxybelis æneus.
DIACRANTERIDÆ.	DIACRANTERIDÆ.	DIACRANTERIDÆ.
Dromicus Antillensis.	Dromicus Antillensis.	Dromicus Antillensis.
Dromicus Cursor.	Natrix atra? G.	Dromicus cursor.
Dromicus anguliferus (Coluber cantherigerus).	Natrix callilæma? G.	Dromicus Pleii.
	Natrix capistrata? G.	
TYPHLOPIDÆ.	TYPHLOPIDÆ.	
Typhlops lumbricalis.	Typhlops lumbricalis.	
Typhlops Richardii.		
		STENOCEPHALIDÆ.
		Homalocranion semicinctum.
		DIPSADIDÆ.
		Dipsas annulata.
		CROTALIDÆ.
		Bothrops lanceolatus.
BATRACHIA.	BATRACHIA.	BATRACHIA.
HYLIDÆ.	HYLIDÆ.	HYLIDÆ.
Hylodes Ricordii.	Litoria luteola, G.	Hylodes Martinicensis.
Trachycephalus marmoratus.	Trachycephalus lichenatus, G.	
Phyllobates bicolor.	Hyla brunnea, G.	
BUFONIDÆ.		BUFONIDÆ.
Bufo peltocephalus.		Bufo Agua.

Hence it would appear, that with the exception of Emys decussata, Crocodilus acutus, Sphæriodactylus sputator, Anolis Sagræi, Leionotus maculatus, Dromicus Antillensis, and Typhlops lumbricalis, unless several of the others have been incorrectly determined, the species belonging to the islands Jamaica and Cuba, although but ninety miles distant, are altogether different, and that several of the genera which exist in the one are wanting in the other. Besides the above we have in our collection a

small serpent of the size of a Calamarian, with a very short and broad frontal (vertical) plate, a large pre-ocular, no loral and broad gastrostega, carinated scales and a double row of black spots along the back, from Jamaica, included in the donation of Dr. Pennock, which is identical with Storeria DeKayi, B. & G. (Ischognathus DeKayi, Dum. et Bib.)* With the exception of Anolis Carolinensis, the reptiles of Cuba differ in their species altogether from those of the United States, even the southern portion of it; and not only so, but with the exception of Emys, Hylodes and Bufo, and perhaps Ischognathus, there does not appear to be even a genus common to the two countries. Were the Herpetology of each of the West India Islands fully known and very accurately determined, many highly interesting and important facts would be developed, tending much to elucidate the laws which govern the geographical distribution of species.

7. *On some young Gar Pikes from Lake Ontario;* by L. Agassiz, (Proc. Bost. Soc. N. H., vi, 48.)—They were remarkable, he said, as still preserving certain embryological characters. The most conspicuous of these was the prolongation of the vertebral column in the form of a fleshy filament, distinct from the caudal fin, which had at times a vibrating motion, involuntary, and quite distinct from the motions of the tail itself, as is seen in some embryos. This singular formation shows that the caudal fin is properly an appendage to the lower surface of the dorsal column, a true second anal, and not the proper termination of the column. The specimens exhibited showed their affinity to reptiles, by their motions and attitudes; the spine being more flexible than in ordinary fishes, and their position, when at rest, being frequently more or less bent, particularly towards the tail; peculiarities arising from the ball and socket joints of the vertebræ,—a proper reptilian arrangement. The manner of feeding also is unlike that of fishes, and resembles that of reptiles. Other fishes take their food with open mouth, and swallow it at once; but this one approaches its prey slyly, sidewise, and suddenly seizing it holds it in its jaws, until, by a series of movements, it succeeds in getting it into a proper position for swallowing, as is the habit with alligators and lizards. The ball of food in the body of this fish is seen to move gradually, as it distends the body in its progress, from one end to the other, as is seen in snakes. This fish is also remarkable for the large quantity of air which escapes from its mouth. The source of this Prof. Agassiz had not been able satisfactorily to determine. At certain times it approaches the surface of the water, and seems to take in air, but he could not think that so large a quantity as is seen adhering in the form of bubbles to the sides of the gills could have been swallowed, nor could he suppose that it could be secreted from the gills themselves. These different interesting facts were noticeable in the specimens exhibited, which were fed for the occasion on live minnows, the only food they could be persuaded to take.

* This species has a wide range, being found in Massachusetts and Georgia. Duméril and Bibron say they have received a specimen from Mexico.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Observations on the Zodiacal Light;* by Rev. GEORGE JONES, U. S. N. (From the Astronomical Journal, No. 100, a letter dated Quito, Nov. 18, 1856.)—You are perhaps, aware that I am spending at this place the time occasionally allotted to officers of the Navy, after a long cruise; and that I am continuing here a series of observations on the Zodiacal Light, commenced in the seas of China and Japan.

The advantages of this place are very great. 1st. I have the ecliptic vertical to me, at some one hour, every night in the year. 2dly. The ecliptic can never, at the farthest, make an angle of less than 66° with my horizon; and therefore the Zodiacal Light must always present itself favorably for observation. 3dly. The transparent atmosphere of this elevated plateau allows me to see objects in the sky with a wonderful degree of distinctness. Hence the distinctive features in every change of the Zodiacal Light can be marked, here, with an exactness that I never witnessed before.

My observations are made on the summit of the hill Ychinbía, immediately adjoining Quito on the east, a place where I have horizons sufficiently open and clear.

It is not my present object to give details of observations, but simply to notice one result, and to offer some queries to which it seems to lead, in hope of now drawing attention to the subject, and perhaps of inducing other observers to give it their particular notice. *I see here every night, and all through the night, a luminous arch, from east to west, quite across the sky.* This arch, 20° wide, is visible at all hours, when the sky is clear, but is brightest and most striking when the ecliptic is vertical; at which times it looks almost like another Milky Way. It is very evidently the Zodiacal Light. This luminous arch, I know, is not a new discovery, for Baron Humboldt saw it in the seas off Mexico, and Professor Brorsen has noticed it more fully in Germany. I also had glimpses of it in my late cruise in the Eastern seas. Here, however, it is developed with a remarkable degree of distinctness, and I am giving it particular attention. I am the more interested in it, from a suspicion which has arisen in my mind, that it is an independent light; that is, that the nebulous substance from which it comes is self-luminous, though also capable of giving us reflected light. This is only yet a surmise, for my observations, of only eleven weeks' continuance, (I have forty-four degrees of this arch recorded,) are yet too few to warrant more than this; and we must have numerous data before we can decide affirmatively on so important a subject. My chief grounds for this surmise now are,—1st, that while the Zodiacal Light, near the horizon (where it obviously is chiefly a reflected light), changes decidedly according to my change of place, as regards the ecliptic, and has a strong reference to my position, the light of the Luminous Arch has not so much reference to this position; 2dly, that while the Zodiacal Light near the horizon has a warm, sunny tinge, the light in the Luminous Arch is a cold, white light, resembling that of the Milky Way; and 3dly, that, while the Zodiacal Light over the horizon tapers off in intensity as it ascends upwardly, this of the Luminous Arch, after this other ceases, is uniform quite across the sky.

All this, however, as you will perceive, is ground only for surmise, and can now only sharpen observation; and it is a subject in which it will not do to hasten to conclusions.

Allow me, in this connection, to throw out some queries suggested in part by this, and in part by other things which I have seen at this place. —The thinness of the air on this plateau, by which, during the day, objects a great way off are seen with remarkable distinctness, and seem to be near by, might be expected to assist in atmospheric developments of several kinds unusual at other places; and such is also the fact. A phenomenon, which has sometimes drawn the attention of philosophers, namely, a general brightness in the air, at night, without any apparent cause for it, is, in some nights, very remarkable here. I find it has been noticed by others as well as myself. The brightness, without moon, or any assignable reason, has been so great, at times, that I have taken out printed papers or books, to ascertain whether I could not see to read by it.

Now, the queries that all this subject appears to suggest to us are these:—1st. May not self-luminosity be an inherent principle of nebulous matter? 2dly. May not all space be occupied by nebulous matter, diffused around in various degrees of tennity, but mostly so thin as to be imperceptible, except in its occasional retardation of heavenly bodies; and, as a part of that query, is it not the cause of this well-ascertained retardation? 3dly. May not the light of what we call nebulæ be from such self-luminous nebulous matter, with stars or suns, its product, but not having absorbed it all, shining in its midst? 4thly. May not the light of our Milky Way itself be, in part, from such self-luminous nebulous matter, there collected in greater quantities than in other portions of our sky? In this case, the changes known in the Galaxy, and sometimes called by astronomers "the breaking up of the Milky Way," will not be a change in stars, but in the less stable substance from which stars and systems of worlds are made.

I offer all this as merely a subject for query; and perhaps even such queries are too bold for the data which we now possess.

In connection with my observations at this place, E. C. Herrick, Esq., at New Haven, Connecticut, Dr. Drayton, U. S. Navy, for a while on board the St. Mary's, at Panama, and Professor Moesta, of the National Observatory at Santiago, Chili, are making simultaneous observations on the Zodiacal Light, on the 1st, 10th, and 15th of each month, each being furnished with star-charts; and we may thus hope for a tolerably full set of results.

In conclusion, allow me to express my regret that there is not an astronomical observatory at or near this place. It seems to me that the whole world should bestir itself, at once, to have one here. It is worthy of a world's union. Or if that cannot be done, why will not some wealthy individual or individuals see it accomplished? There is much cloudy weather here; but when the nights are clear, they have a most surprising brilliancy, the smaller stars coming out so as to fairly crowd the firmament, and the Milky Way appearing with a brightness, and apparently a nearness, that is wonderful to behold. I have no doubt that an observatory here, even if the instruments were not of very extraordinary power, would make very interesting revelations in this science. The climate here is agreeable and healthy; living is very cheap; the

government of Ecuador, to my knowledge, would be very glad to coöperate in such a matter, though they have themselves not the means. Why cannot it be done?

2. *On the Meteor of July, 1856;* by THOMAS M. PETERS.—On Tuesday, the 8th day of July, 1856, I was on the road leading from *Moulton*, (Ala.) to *Columbus*, (Miss.), about six miles south of *Thorn-hill* in Hancock County, Alabama. At about six o'clock in the evening, my friend, B. R. Delgraffenreid, Esq., who was with me, called my attention to a remarkable meteor, then falling. When I turned my eyes upon it, it was just too late to get a distinct view of it; but my friend, who saw it clearly described it, as very brilliant and startling, and six or eight inches in apparent diameter. It made its appearance or rather seemed to burst through the concave of the heavens, at a point near midway between the zenith and the horizon, and some thirty or thirty-five degrees west of south from our place of observation. It seemed to fall almost perpendicularly downwards, with a slight curving to the eastward. From the points of first appearance, it descended with great swiftness, until it reached a stratum of reddish-dun colored cloud, at about ten degrees above the horizon. In this cloud it seemed to disapper. *Above* the cloud, into which it seemed to fall, it left a long *train* of whitish smoky color, which gradually tapered, from the base upwards, in a well defined slender cone, regularly rounded at the apex, with ventricosely-waved margins—but perfectly distinct throughout. The color of the *train* was about that of *thick steam*, at low working temperature, and very much resembled it, except it was much more permanent. The singular peculiarity of the margins of the *train* suggest, that it may have been occasioned by some gaseous substance projected forward from the body of the meteor with considerable velocity, against the opposing atmosphere, which curved it backwards, (upwards in this instance), and outwards, in rolls; as happens to the smoke from the mouth of a cannon. These indications of violent projection were frequently, and somewhat regularly, repeated from the top to the bottom of the *train*. The breadth of this *train* was, apparently, about four inches at the top, and about eight or nine inches at the bottom. In color it was somewhat darker at the upper end, than it was below; and seemed to grow paler and thinner, from the top, downwards. It continued stationary throughout, and remained without apparent change for about ten or twelve minutes. Then it began to grow paler, and shortly afterwards became invisible. The whole *train* was vividly distinct in all its outlines, and remained visible about fifteen minutes, by my watch. At last, it began to disappear from the *top*, downwards, and seemed to fade away without dispersing, as if it had been absorbed as it stood.

There was no appearance of the meteor or its singular train *below* the cloud, into which it seemed to fall. There was no noise of explosion heard, though we listened attentively. At our place of observation it was calm and fair, though in the direction of the meteor it was cloudy; and as I learned afterwards, it rained heavily in the afternoon of that day, The position of this meteor from our point of observation, indicated that it must have fallen in the direction of *Columbus*, (Miss.): therefore it could not have been Prof. Harper's meteor, which was seen farther north, at Orford in that State, on the same day.

Moulton, Ala., Nov. 25th, 1856.

3. *On Dellman's Method of Observing Atmospheric Electricity;* by Prof. W. THOMSON, (Proc. Brit. Assoc., August, 1856; Ath., No. 1505.) The author said:

"During my recent visit to Creuznach I became acquainted with Mr. Dellman of that place, who makes meteorological, chiefly electrical, observations for the Prussian Government, and I had opportunities of witnessing his method of electrical observation. It consists in using a copper ball about six inches diameter, to carry away an electrical effect from a position about two yards above the roof of his house, depending simply on the atmospheric 'potential' at the point to which the center of the ball is sent; and it is exactly the method of the 'carrier ball' by which Faraday investigated the atmospheric potential in the neighborhood of a rubbed stick of shell lac, and other electrified bodies ('Experimental Researches,' Series IX, 1839.) The whole process only differs from Faraday's in not employing the carrier ball directly, as the repeller in a coulomb-electrometer, but putting it into communication with the conductors of a separate electrometer of peculiar construction. The collecting part of the apparatus is so simple and easily managed that an amateur could, for a few shillings, set one up on his own house, if at all suitable as regards roof and windows; and, if provided with a suitable electrometer, could make observations in atmospheric electricity with as much ease as thermometric or barometric observations. The electrometer used by Mr. Dellman is of his own construction (described in Poggendorff's 'Annalen,' 1853, vol. 89, also vol. 85), and appears to be very satisfactory in its operation. It is, I believe, essentially more accurate and sensitive than Peltier's, and it has a great advantage in affording a very easy and exact method for reducing its indications to absolute measure. I was much struck with the simplicity and excellence of Mr. Dellman's whole system of observation on atmospheric electricity; and it has occurred to me that the Kew Committee might be disposed to adopt it, if determined to carry out electrical observations. When I told Mr. Dellman that I intended to make a suggestion to this effect, he at once offered to have an electrometer, if desired, made under his own care. I wish also to suggest two other modes of observing atmospheric electricity which have occurred to me, as possessing each of them some advantages over any of the systems hitherto followed. In one of these I propose to have an uninsulated cylindrical iron funnel, about seven inches diameter, fixed to a height of two or three yards above the highest part of the building, and a light moveable continuation (like the telescope funnel of a steamer) of a yard and a half or two yards more, which can be let down or pushed up at pleasure. Insulated by supports at the top of the fixed part of the funnel, I would have a metal stem carrying a ball like Dellman's, standing to such a height that it can be covered by a hinged lid on the top of the moveable joint of the funnel, when the latter is pushed up; and a fine wire fixed to the lower end of the insulated stem, and hanging down, in the axis of the funnel to the electrometer. When the apparatus is not in use, the moveable joint would be kept at the highest, and its lid down, touching the ball so as to keep it uninsulated. To make an observation, the lid would be turned up rapidly, and the moveable joint carrying it let down, an operation which could be effected in a few seconds by a suitable mechanism. The electrometer would immediately indicate an

inductive electrification simply proportional to the atmospheric potential at the position occupied by the centre of the ball, and would continue to indicate at each instant the actual atmospheric potential, however variable, as long as no sensible electrification or diselectrification has taken place through imperfect insulation or convection by particles of dust or currents of air (probably for a quarter or a half of an hour, when care is taken to keep the insulation in good order). This might be the best form of apparatus for making observations in the presence of thunder-clouds. But I think the best possible plan in most respects, if it turns out to be practicable, of which I can have little doubt, will be to use, instead of the ordinary fixed insulated conductor with a point, a fixed conductor of similar form, but hollow, and containing within itself an apparatus for making hydrogen, and blowing small soap-bubbles of that gas from a fine tube terminating as nearly as may be in a point, at a height of a few yards in the air. With this arrangement the insulation would only need to be good enough to make the loss of a charge by conduction very slow in comparison with convective loss by the bubbles, and it would be easy to secure against any sensible error from defective insulation. If 100 or 200 bubbles, each $\frac{1}{10}$ inch in diameter, are blown from the top of the conductor per minute, the electrical potential in its interior will very rapidly follow variations of the atmospheric potential, and would be at any instant the same as the mean for the atmospheric during some period of a few minutes preceding. The action of a simple point is, (as I suppose, is generally admitted) essentially unsatisfactory, and as nearly as possible nugatory in its results. I am not aware how flame has been found to succeed, but I should think not well in the circumstances of atmospheric observations, in which it is essentially closed in a lantern; and I cannot see on any theoretical ground how its action in these circumstances can be *perfect*, like that of the soap-bubbles. I intend to make a trial of the practicability of blowing the bubbles; and if it proves satisfactory, there cannot be a doubt of the availability of the system for atmospheric observations.

4. *On the Tides of Nova Scotia;* by Prof. Chevallier, (Proc. Brit. Assoc., August, 1856; Ath. No. 1505.)—The observations to which reference is made were taken by a tide-guage fixed upon a wharf at the north end of the naval yard at Halifax. The tides there are small in amount, the spring tides rising from 6½ to 9 feet at Halifax, and 8 feet at Sambro Isle, 12 miles south of that place. The tides themselves appear to be quite regular; but in addition to the ordinary tide-wave there occurs a series of undulations succeeding each other at intervals of twenty minutes or half an hour, the difference of elevation and depression rarely exceeding six inches, and being usually much less. They are more perceptible near low water; but occur at all times of tide, and are very distinctly marked upon the curve traced by the self-acting tide-gauge. The question to be considered is, what is the cause of these small waves? 1. They do not arise from any influence which the casual swell of the sea might exercise upon the tide-guage,—for the rise and fall of one of these waves very seldom takes less time than a quarter of an hour, and often requires half an hour, or even three-quarters of an hour. 2. They do not arise from undulatory motion in the whole waters of the harbor. In

order to examine this question, Mr. Edgcumbe Chevallier, the storekeeper in Halifax Dockyard, went to Sambro, ten or twelve miles south of Halifax, and entirely clear of the harbor, and erected upon Power Island a temporary guage, with which he took the height of the water every five minutes for the whole day. Having laid off the results in a form similar to that employed with the fixed tide-guage at Halifax, it was found that every irregularity at Halifax was preceded ten or fifteen minutes by a larger irregularity at Sambro. These observations show that the irregular waves do not arise from the peculiar form of the harbor at Halifax. 3. At about sixty miles eastward from Halifax, outside Sable Island, the gulf-stream runs in nearly a northeastern direction with considerable velocity; and, between Sable Island and the land, a counter-current runs in nearly a south-western direction. One of these currents would elevate the surface of the sea near the middle of the currents; and such an elevation of the surface over which the tide-wave is propagated might give rise to undulations similar to those observed. I am informed, however, that the undulations in question are observed on the western side of Nova Scotia, to which any effect of those two currents could not extend. 4. Although the tides at Halifax and on the neighboring coast are small, that part of the ocean is near the indraught of the Bay of Fundy, where the peculiar form of the coast and its position with reference to the great tide-wave of the Atlantic give rise to a local forced tide of excessive magnitude. Such a tide, especially when reverberated from coast to coast in a comparatively narrow inlet, might not improbably give rise to perceptible undulations in a neighboring part of the sea. If this be the cause, it might be expected that a similar effect should be noticed where a forced tide of the like nature takes place. The Bay of Avranches is a locality of this kind, and the island of Jersey appeared to be a place where any undulations of the tide might probably be noticed. The extreme difference between high and low water at St. Helier's is forty-two feet, and the difference of height of the mean high and low water is thirty-six feet. On inquiry, I find that about ten years since a tide-guage was fixed at St. Helier's, but observed only at high water, when irregularities were observed of the same kind as those noticed at Halifax. This seems to give probability to the opinion that the irregularities observed in the tide at Halifax may be connected with the unusual tides in the Bay of Fundy. But whether they rise from this source, or are to be traced to some great reciprocating motion to which the waters of the Atlantic may be subject, the phenomenon deserves to be studied, as likely to lead to a more extended knowledge of the hydrodynamical conditions of our globe.

5. *Notice of a visit to the Dead Sea;* by H. Poole, Esq. (Proceedings Quar. Jour. Geol. Soc., xii, 203. Forwarded from the Foreign Office by order of Lord Clarendon. Abstract.)—Mr. Poole went to this district to look for nitre, which was reported to occur there; but he met with none, and found reason to suppose that the report was unfounded. The same word in Arabic means "bitter or rock salt," as well as "nitre," hence possibly the erroneous information. Further, the cave (at Usdum) in which the nitre was said to have occurred is called "the cave of the Gun-men," not from the Arabs getting their nitre there for gunpowder,

but as the spot from which they watch for the crossing of the hostile tribes across the plain.

Mr. Poole and Mr. E. Mashallam spent nearly two days at Usdum, going to several caves (in which fine stalactites of salt occur), climbing nearly to the top of the mountain, and walking about the shore, but in no instance could they find a deposit or even a sample of nitre. Mr. Finn, H. M. Consul at Jerusalem, also informed Mr. Poole that he had never seen any; nor had the Sheik Aboo Daook and his men. The Arabs generally make their own nitre by boiling the dung of goats; others scrape it off old walls or limestone-caves, but never in any large quantity.

The Arabs charge 60 piastres or 10 shillings for a camel-load of salt, about 500 lbs., delivered in Jerusalem, and the purchaser pays the Turkish government 15 piastres more for duty. Each camel will make about twenty-four trips in a year, thus carrying altogether 12,000 lbs. a year.

From Usdum Mr. Poole proceeded to El Lisan (the Peninsula), and travelled all around it. The ridge of high land is highly impregnated with sulphur; but the nodules of native sulphur are very rare.

At the present time it would be almost impossible to do anything on El Lisan, for the road between it and Usdum is open to the attacks of four independent tribes of Bedouins, including the Sultan of Kerak, over whom the Turkish government has no control.

Previously to visiting Usdum, Mr. Poole made a trip to the northern end of the Dead Sea. At Nebi Mousa (half-way from Jerusalem to the Dead Sea), there is a quantity of bituminous shale or "blind coal," from which ornaments are cut; and a thick bed of soil highly impregnated with sulphur occurs there. Nothing but saline incrustations were found on the north shore of the Dead Sea.

6. *Modification of the Barometer.*—M. Secchi proposes to substitute a method of measuring the changes in a barometer by *weight*, instead of the ordinary method by *volume*. The barometer is made with a large tube to make the amount of mercury greater, and is moveable up and down in the cup below; then, since the power to raise it will be equivalent to the weight of the atmosphere, the weight ascertained by a balance, or an index with a graduated scale, gives the atmospheric pressure with far more nicety than by the ordinary mode of sighting. If the tube has a section 10 centimeters square, and the pressure vary 1 centimeter in height, the total addition of weight will be 10 cubic centimeters of mercury, equal to 135 grammes, while if the tube were but 1 centimeter square, it would be but $13\frac{1}{2}$ grammes. This shows the advantage of a large tube. M. Secchi has constructed such a barometer for the College at Rome, which has the tube 15 millimeters in diameter. The variation of a tenth of a line in the mercury is marked by an index moving 6 lines.

The author observes also that with a large tube, the amount of mercury is so great that the movement may be used for moving a pencil for self-registration. Moreover the method is independent of the purity of the mercury, of temperature, and of the difference of gravity in different latitudes. In addition, the tube may be made of iron, or of any metal not acted on by mercury, instead of brittle glass, and there will not be any trouble from the adhesion of the mercury or from humidity, and

the mercury may be boiled easily without danger of breaking. Barometers may consequently be made of water or other liquids in the same way, since metal tubes may be made of any length.

7. *On the Telescopic Stereoscope;* by JAMES ELLIOT, (Philosophical Magazine and Journal, Jan., 1857.)—I have recently succeeded in constructing what I believe to be a new form of the stereoscope. Its object is to unite *large* binocular photographic pictures in a different way from any that has hitherto been followed.

The pictures are placed side by side, and viewed through two small telescopes, like those of opera-glasses, with the directions of their axes crossing each other; the left-hand picture being viewed with the right eye, and the right-hand picture with the left eye. The two telescopes are connected together, the connecting apparatus being capable of two adjustments; one to suit the width of the eyes, and the other to give the obliquity required. When the instrument is placed on a stand, as I have it, two other adjustments are required; the first to bring the telescopes to the proper elevation, and the second to bring the plane of their axes into parallelism with the upper or lower margins of the pictures.

The instrument is constructed in such a way that these adjustments are made with great facility; and when the pictures are united, the effect is excellent.

8. *Amos Binney's "Terrestrial Mollusks and Shells of the United States."*—Mr. W. G. BINNEY, (son of the late Dr. Amos Binney, who died after having published two volumes of his admirable work on the United States land Mollusks,) announces that he is engaged in preparing a continuation of the work of his father, and solicits assistance by way of land shells and information relating to the subject, with any addenda or corrigenda to the volumes published. We trust that Mr. Binney may be liberally aided in his undertaking. He resides at Germantown, near Philadelphia.

9. *Mastodon.*—A portion of a jaw has been found near Columbia, in California.—*Proc. California Acad. Nat. Sci.*, i, 27.

10. OBITUARY.—*Death of Wm. C. Redfield.*—As the last sheets of this number are passing through the press we hear the sad tidings of the death of WILLIAM C. REDFIELD, of New York. After an illness of about two weeks he died at his residence in that city, Feb. 12, 1857, aged 68. We make this record with emotions of more than common sorrow, for Mr. Redfield was a man whom, through a long course of years, we had honored as a philosopher, and loved as a friend. He was born at Middletown in this State, and with very limited advantages of early education, he rose from a humble position, and earned for himself a high rank among men of science. In early manhood he removed to New York City, where he thenceforward continued to reside, engaged in business connected with steamboat navigation and transportation on the Hudson. In the midst of active business he found time for self-improvement and for scientific inquiry and study. Although he took great interest and pleasure in many departments of science, he gave special attention to Geology, Physical Geography and Meteorology. In these fields of learning he did not content himself with becoming acquainted with the re-

sults of others, but was himself a diligent laborer. Mr. Redfield was one of the original members of the "Association of American Geologists and Naturalists," and when in 1847 that body agreed to resolve itself into the "American Association for the Advancement of Science," he was chosen its first president. At an early day he foresaw the great value of railroads in developing the resources of our country, and in 1828 he published a pamphlet indicating the most feasible route for a road to connect the Atlantic and the Mississippi, a route which was substantially adopted, and the last link of which was completed in 1854. But his most important labors were devoted to Meteorology, and his researches and discoveries in this science have rendered his name familiar throughout the nautical and scientific world. In the year 1821 his attention was directed to the investigation of a violent storm which had a short time previous passed through New England, and on collecting and sifting all the observations he could obtain, he came to the conclusion that this storm was *a travelling whirlwind*. This important discovery he followed up by collecting and studying observations and reports on the gales of the Atlantic and the hurricanes of the West Indies. He found that these storms were of the same general character, revolving in the same direction and pursuing paths essentially similar. Restrained by his characteristic modesty, Mr. Redfield did not publish his discoveries until at the urgent solicitation of Professor Olmsted he brought them out in the 20th volume (1831) of the first series of this Journal. From that time up to the close of life, his labors in this field of research have been most industriously continued, and the results have been made public principally through the medium of our Journal. Extending his inquiries to the gales and hurricanes of all parts of the world, he found those of the Northern hemisphere alike in direction of rotation and in course of travel, while those of the Southern hemisphere were found to revolve in the opposite direction and to pursue a reverse line of travel. In 1838, Lt. Col. Reid, of the British Royal Engineers, published at London a large volume entitled "An Attempt to develop the Law of Storms," in which work he adopted Mr. Redfield's views, ably supporting and extending them by new observations. Since that time the same doctrines (while they have not been universally accepted at home) have been embraced by several foreign authors, and have been reproduced in various publications.

Mr. Redfield's discoveries are valuable not merely to theoretical science; they are of great practical importance to the navigator. As early as the year 1834, (in Blunt's Amer. Coast Pilot, and vol. xxv, 1st ser. of this Jour.) he published some brief instructions to seamen, showing them how to avoid the fury of a gale in which they might be overtaken. Many intelligent navigators and naval officers have borne testimony to the great value of the directions, based on his theory, which have from time to time been published, for escaping storms at sea.

Mr. Redfield was a sagacious observer, an industrious collector of facts, an active and original thinker. In all the various relations of life the excellency of his character was conspicuous, and he approached the closing scene sustained by a humble trust in his God and Saviour.

We hope to present in some future number a fuller account of the life and labors of our departed friend.

11. *Hugh Miller.*—Hugh Miller, one of the best known and most honored of Scotland's sons, died at Portobello, near Edinburgh, his place of residence, on Wednesday the 24th of December. In consequence of excessive mental labor his mind had become disordered, and under derangement, he died by his own hand. He had just finished a new work, one of a series that has done more than all else published in the world to popularize and christianize science; and he leaves this "Testimony of the Rocks" as a testimony to his own greatness and goodness of soul, as well as to the treasures of wisdom in the volume of creation which he so delightingly read.—We cite the following from accounts abroad of this sad occurrence.

"Most people know that Hugh Miller has been a hard worker. He has not wrought out his way from the stone-mason's quarry to so distinguished a position in science and literature without living a life of incessant and wearing mental toil. In fact, he had worked much too hard and constantly. And, although a man of sturdy *physique*, his brain was unable to stand the stress of his will and the strain of his perseverance. Latterly, in addition to fulfilling the duties of editor of a newspaper, published twice a-week, he had been working very determinedly at his new geological work, to be called 'The Testimony of the Rocks.' His brain had become over-wrought; he was restless at night, and could obtain no refreshing sleep. This had most probably increased a latent tendency to walk in his sleep, which he had often mentioned to friends. His children have at times awoke during the night, and seen him pacing their bedroom in the somnambulistic condition. Indeed, on Monday last, he told a friend that he suspected having been out in the garden in the night, and in this abnormal state. Another cause of his over-excitement and derangement—for such a medical examination finds to have existed—may be found in the fact that he has suffered greatly of late from terror at the depredations of the 'ticket-of-leave' men, dreading lest they might break in and rob his museum of some of its cherished rarities. So much had this fear affected him, that he has asserted attempts to have been made upon that part of his house, although this was most probably an illusion. Mr. Miller has been accustomed to keep fire-arms for years past, and has been known to seriously present a pistol in his own defence when suddenly accosted in a street at night. He slept with a loaded pistol at the side of his bed. In consequence of his wife's long illness and his keeping late hours in his study, he had lately slept in a bed adjoining the study, which was at some distance from the sleeping apartments of the family. After seeing his medical advisers on Tuesday, and having been told that cessation from work was necessary, he went to bed somewhat early on Tuesday night, after using a sponge bath that had been prescribed. What caused him to get up in the night can never be known. The horrible trance, more horrible than ever, must have returned. All that can now be known of what followed is to be gathered from the fact that next morning, his body, half dressed, was found lying lifeless on the floor, the feet upon the study rug, the chest pierced with the ball of the revolving pistol which was found lying in the bath that stood close by. The body was lifted and laid on the bed. We saw it there a few hours afterwards. There was the massive brow, the firm-set, manly features,

we had so often looked on admiringly, just as we had lately seen them, nothing but that overspread pallor of death to distinguish them from what they had been. We could not help thinking as it lay there in unruffled majestic repose, that the spirit had passed through a terrible tornado, in which reason had been broken down, but that it had made the great passage in safety, and stood looking back to us in humble grateful triumph from the other side.

"The announcement of the death of Hugh Miller will be heard with a thrill of genuine sorrow throughout the church in which he was a standard-bearer,—throughout Scotland, of which he was one of the most conspicuous ornaments,—throughout the world of science, which associates his honored name with those of the men most distinguished in our day, as fellow-workers in building up the stately fabric of the modern geology. * * To Mr. Miller, more than any other geologist, undoubtedly belongs the honor of having demonstrated, what previous observers had begun to suspect, that the Old Red Sandstone was entitled to rank as an independent formation, by its distinctive fossils, many of which he was the first to discover and describe. Mr. Miller had projected, and had advanced far in the preparation of a work on the general geology of Scotland; but it is with the Old Red Sandstone that his name as a geologist will be permanently connected. The work in which he traces the progress of his observations, has been probably perused more for its moral interest and its literary excellences than even for its geological descriptions. It is such a book as Oliver Goldsmith might have written, had he been a naturalist, which he was not. * * * To Mr. Miller's versatile talents, and the varied contributions of his pen to criticism, art, philosophy, and science, is applicable, also, more than to any other writer of the day, the panegyric pronounced upon Goldsmith, that there was no branch of knowledge which he did not touch, and which, touching, he did not adorn. His most profound work, the "Footprints of the Creator, or the Asterolepis of Stromness," is a contribution to natural theology of inestimable importance. It has been adopted as a text book by some of the most eminent teachers of geology in the Universities; and it has done more to expose the atheistical fallacies and sophistries of the "Vestiges of the Natural History of Creation" than even the elaborate essays of Sedgwick and Brewster. We rejoice that Mr. Miller has written his own biography. "My Schools and Schoolmasters" is a work already familiarly known.

"Thousands here and in other lands will join with us in the tribute of an honest tear to the memory of a man of true heart and noble powers of intellect, devoted to the loftiest purposes. Little did we think, when we met Mr. Miller last year, in the genial and kindly intercourse of the British Association, that we were to see his face no more; and that at the early age of fifty-four, he would be lost to the Church which he loved, and to the cause of Christian science, which owes so much to his example and labors. Death has made sad inroads of late years upon the ranks of the cultivators of natural science. Dr. Landsborough, Professor Edward Forbes, Dr. Johnston of Berwick, Mr. Yarrell, and now Mr. Hugh Miller, have passed away in rapid succession,—and Forbes and Miller have left behind them no equals."

12. *Gregory's Handbooks of Chemistry, Inorganic and Organic.**—A careful reprint of the latest English edition of Dr. Gregory's 'Handbooks' (the English editions of which are marred by numerous typographical errors) would be a valuable addition to our chemical literature. The volumes before us purport upon their titles to be such reprints, the one from the third, the other from the fourth English editions. But after a careful comparison of their several pages with the original we are sorry to say that they belie their titles. They are in fact printed almost wholly from the old stereotype plates of an American edition by the same editor, issued at Cincinnati in 1851 (July), and copied from the English edition of 1846 (Inorganic) and 1847 (Organic). So entirely is this edition reproduced from the old plates, that the erroneous references copied from the English original stand unchanged in this and refer to nothing! (e. g. on p. 15 (organic) we are referred to *cyanogen* and *mellone* in part i, p. 140—i. e. in the American reprint to *galvanic decomposition*—while the reference is unaltered from the original English edition of 1847 now before us.) Even the trivial typographical inaccuracies which any careful proof-reader should have corrected remain unchanged. In fact the old plates have been used by the new publishers, who are responsible with their editor for this bold attempt to deceive the public by passing off old wares with new labels. We have found it difficult to avoid in this connection the use of language which, however it might be justified by the aggravation of the case, is not appropriate here.

But it will be said, the American editor of these volumes has undertaken to supply to the inorganic chemistry the Physics of Chemistry, and to add to the organic part a "supplement," which is said to bring the science down to the last moment. The manner in which he has discharged these editorial labors it is our duty briefly to point out. In the "Preface" we are informed that "the original work of Dr. Gregory does not contain the imponderables, a very important department of modern chemistry. The first American edition was therefore devoid of *light*, *heat*, and *electricity*, an oversight which was felt by *those many* [the italics are ours] American professors who have adopted this work in *their colleges* as one which was almost inexcusable." Dr. Sanders has undertaken to supply this assumed deficiency in Dr. Gregory's handbook, and in contemplating the results of his labors to this end discourses as follows, in the preface. "Whilst the matter prefixed to this invaluable work of Dr. Gregory cannot be designated a compilation, the greater portion of it being written in the language of the editor" [no one, we feel quite sure, will dispute this modest claim to authorship], "it still cannot aspire to the dignity of an original composition." "The entire subject of the Imponderables is condensed as

* *Handbook of Inorganic Chemistry, for the use of students*, by William Gregory, M.D., F.R.S.E., Professor of Chemistry in the University of Edinburgh. 4th American from the 3d English edition, to which is added *The Physics of Chemistry*, by J. Milton Sanders, M.D., LL.D., Professor of Chemistry in the Eclectic Medical Institute of Cincinnati, Member of the American Association for the Advancement of Science, etc. New York: A. S. Barnes & Co., 51 and 53 John st. 1857. 8vo, pp. 426.

Handbook of Organic Chemistry, by the same. 4th American from the 4th London edition, with a Supplement. 8vo, pp. 480.

much as possible, therefore the writer has not thought it expedient to insert the many long and prolix tables upon the subject of heat which the larger works upon Physics contain." "At the same time we venture the assertion, that in the condensed matter contained in this volume the student will not fail to find the laws of these sciences, and the principal facts associated with their revelation clearly explained."

Dr. Gregory is an able chemist, and has the merit of being the chief expounder in our language of the chemical school of Liebig. We can readily imagine the vexation he must feel, and with it the unavoidable contempt for American science, at the manner in which his handbooks are here presented. It has never been our misfortune to see any good book more sadly spoiled by the bungling of an editor. His ignorance of his subject is equalled only by his audacity, and his short-comings in syntax. These broad assertions find ample illustration and support on every page which is not a literal reprint from Dr. Gregory. His bad English is seen in what we have already cited. Under Light we are told "That great philosopher (Newton) proved that light does not present—in the language of one who lived before him—'an instance of homogeneity'—but that it is really of a composite nature, and constituted of even more energies than he supposed." That is, Newton proved more than he was aware of. The student is informed (p. 39) that "the hypothesis of the undulations or waves in an attenuated ether, may perhaps, for the present answer for the luminous rays, but it will not stand the test in regard to those more refrangible ones which produce chemical action."

The following felicitous sentences introduce the student to chromatic polarization. "The following diagram (copied from Woodward) will illustrate the production of color by polarized light. It supposes that light is manifested by the vibrations of an attenuated medium termed the luminiferous. We have in another place given our reasons wherefore we regard the sun's light as a compound consisting of several activities. Perhaps, *for the present*, the calorific rays may be regarded as vibrations of the luminiferous medium, although this is not proved, and therefore should not be accepted as an ascertained truth.* That the diagram may be rendered as intelligible as its inventor, Mr. Woodward, has done in his able work upon polarized light, &c." With no adequate statement of the general phenomena of light, the chemical student is at once plunged into the irrelevant subjects of the "refraction of light through lenses," "spherical aberration of lenses," "chromatic aberration," and "polarization." Ninety pages (out of 191 devoted to the Physics of Chemistry) are given to Light, and of these over 50 are occupied by "Actino-Chemistry," giving numerous minute and technical details for the various processes of photography, which, granting their importance in their proper place, are completely out of place in a handbook of elementary chemistry.

* Dr. Sanders seems to labor under a deep conviction that the whole theory of physical optics stands upon a basis of such unstable equilibrium, that unless he constantly reminds his readers of the fact, some of them may unfortunately rest too much confidence in it.

This introduction upon chemical physics is also open to criticism, not only for errors in statement but for the omission of important subjects which belong peculiarly to chemical physics—the molecular condition of matter—the simple laws of crystallography—the mechanical properties of gases—the methods of volumetric analyses are not mentioned—while the student is entertained by an account of the editor's physiological experiments in removing mercury from the human system by the voltaic current and by examples illustrating the use of this force in medical practice.

Passing now to the organic chemistry, we find on the title page that it is reproduced from the text of the *fourth* English edition. The *fourth?* We have most carefully compared this reprint with the various editions page by page, and it is nothing but *the old stereotype plates of the Cincinnati edition* (1851) without the least change until the close of the 346th page, and is copied from the English edition of 1847. From the 346th page under the head "Nutrition of plants and animals," it is copied from the *third* English edition, also without change. But the "supplement," does not that lessen the force of this grave charge? The prefatory note of the American editor is perfectly in keeping in style with what we have already quoted. The editor is painfully impressed with the impossibility of evolving order out of the confusion of his subject. "The indefatigable industry of chemists has resulted in the accumulation of such a vast mass of knowledge, such a formidable array of isolated facts, that the author of an elementary work like this, is indeed greatly perplexed to select that which is most appropriate. *The editor, even in the preparation of the supplement to this work has encountered this difficulty in all its significance.*" * * "If we are not yet cognizant of the rational formula of a compound then we are not prepared to place it in its undeviating position in a scientific arrangement of organic compounds. *With these considerations uppermost in our mind, we have discarded the idea we at first conceived, of attempting a scientific arrangement of the substances we have presented in the Supplement.*" * * "Prof. Gregory has attempted a methodical and scientific arrangement of the products and theories of organic chemistry in the work we present to the student, and perhaps his arrangement is as scientific an exposition of the doctrines of the science as it is possible to adduce in its present state."

What does all this mean? Plainly, that the American editor has accomplished some great results, and that the supplement is where we must look for them. We have taken the pains to compare it carefully with the English editions of Dr. Gregory and have found that it is made up entirely (with trifling exceptions only), of extracts from the third edition of Gregory, and virtually without any acknowledgement whatever. These extracts are almost wholly on those topics which are not found in the edition of 1847, but they are printed in this supplement with no reference to the parts of the text which they illustrate, and not always in consecutive order. As the chemical reader turns over the pages of this part of the book he is startled at seeing among the *novelties* of the science, Dr. Gregory's chapter on chemical homologues entire—then one and another such old novelty. The most ludicrous anachronisms grow out of this mode of proceeding. Thus on page 431 he re-

produces among the novel records of the science the same paragraph on *Kakodyle* which appears in its proper place in the text of his own edition on p. 160.

On p. 433 we are told "There are several combinations of ethyle with the metals, phosphorus, &c., which have been discovered, *quite lately*, and which it is important the student should be acquainted with. For instance," and then borrowing verbatim from Dr. Gregory's 3d edition, p. 223, &c., he gives us Zyncethyle, Stibethyle, &c., of refreshing novelty!

But enough of this! It is painful to see the evidence of such charlatanry, and more painful to be compelled to expose it. It would seem perhaps improbable that any chemical teacher would be misled into the adoption of this edition of Gregory in his classes; yet it is unfortunately too true that it is the habit of many school committees and boards of trustees arbitrarily to adopt text books without consulting teachers, and by an exercise of the same arbitrary power to select persons who know nothing of a subject as teachers.

The matter is made worse by the fact that the work is published by a most respectable house, who certainly did themselves and the public an injustice that they did not take counsel of their numerous scientific friends, before committing themselves to this unfortunate enterprize.

13. *Proceedings of the Geological Society of London, No.* 47.—The more important papers are:—On the raised beaches of the Western Islands, by Capt. J. Bedford. They are 40 feet above mean tide level.—Rev. S. Haughton on the Granites of Ireland.—Prof. Owen on Gastornis Parisiensis; the specimen a tibia 11½ inches long, or within 1½ inches of the length in an ostrich; found in the Lower Eocene conglomerate at Meudon, near Paris, lying between the Plastic clay and the chalk.—Prof. Owen on Mammalian Remains of the Red Crag of Suffolk (Rhinoceros, &c.).—J. W. Salter on the fossils of the Longmynd Rocks; a new sea weed or zoophyte, traces of marine worms and a Trilobite referred to a new genus and called Palæopyge Ramsayi.—Prof. R. Harkness on the lowest Sedimentary Rocks of the South of Scotland.

No. 48.—T. Wright on the Palæontological and Stratigraphical Relations of the so-called "Sands of the Inferior Oolite."—G. Poulett Scrope, on the formation of Craters and the nature of the liquidity of Lavas.—J. C. Moore, on the Silurian Rocks of Wigtownshire.—S. P. Woodward, on an Orthoceras from China.—J. Prestwich, on the Correlation of the Middle Eocene Tertiaries of England, France and Belgium.

14. *Proceedings of the California Academy of Sciences.*—These proceedings were commenced in Sept. 1854, and the last number received is dated May 12, 1856. They contain many valuable scientific papers, especially on the Fishes of that country by Dr. Wm. O. Ayres and Dr. W. P. Gibbons. There are also geological articles by Dr. J. B. Trask, botanical papers by Dr. A. Kellogg and Dr. Behr. Page 40, Dr. Trask describes an Ammonite (Ammonites Batesii) from Arbuckle's Diggings, Shasta Co., California; p. 41, Tertiary Fossils of Santa Barbara and San Pedro; also new species of Ammonite (A. Chicoensis) and Baculite (B. Chicoensis) from the rocks of Chico Creek, referred by the

author to the Tertiary; description of three species of Plagistoma from the Cretaceous Rocks of Los Angeles, with a plate. Also a paper by Mr. Wm. Stimpson on some Californian Crustacea.

15. *List of Works published by the Smithsonian Institution, Washington, D. C.**—

Quarto volumes.—Smithsonian Contributions to Knowledge. 1848. Vol. I, 4°, pp. 346, with 48 plates and 207 woodcuts. Contains No. 1.

Smithsonian Contributions to Knowledge. 1851. Vol. II, 4°, pp. 464, and 24 plates. Price $5,50, cloth; $5, paper. Containing numbers 3, 12, 20, 13, 14, 16, 17, 23, 15, 4, 6, 7, 11.

Smithsonian Contributions to Knowledge. 1852. Vol. III, 4°, pp. 564, and 35 plates. Price $7, cloth; $6,50, paper. Containing numbers 35, 36, 30, 32, 22, 33, 34, 29, 24.

Smithsonian Contributions to Knowledge. 1852. Vol. IV, 4°, pp. 426. Price $5, cloth. Containing number 40.

Smithsonian Contributions to Knowledge. 1853. Vol. V, 4°, pp. 538, and 45 plates. Price $7,50, cloth, colored plates; $6, uncolored, in paper. Containing numbers 44, 41, 45, 43, 42.

Smithsonian Contributions to Knowledge. 1854. Vol. VI, 4°, pp. 476, and 53 plates. Price $6, cloth. Containing numbers 46, 60, 61, 50, 52, 58, 54.

Smithsonian Contributions to Knowledge. 1855. Vol. VII, 4°, pp. 252, 70 woodcuts and 74 plates. Price $6. Containing numbers 59, 63, 70, 72, 73.

Smithsonian Contributions to Knowledge. 1856. Vol. VIII, 4°, pp. 556, 9 plates and 27 woodcuts. Price $6 cloth; $5 paper. Containing numbers 71, 81, 80, 82, 84, 85.

Smithsonian Contributions to Knowledge. Vol. IX. (In press.)

Mathematics and Physics.—(33) The law of deposit of the flood tide: its dynamical action and office. By Charles Henry Davis, Lieut. U. S. Navy. 1352. 4°, pp. 14. Price 10 cents.

(35) Observations on terrestrial magnetism. By John Locke, M.D., M.A.P.S. April, 1852. 4°, pp. 30. Price 25 cents.

(36) Researches on Electrical Rheometry. By A. Secchi. May, 1852. 4°, pp. 60, and 3 plates. Price 60 cents.

(80) The Tangencies of circles and of spheres. By Benjamin Alvord, Major U. S. Army. January, 1856. 4°, pp. 16, and 9 plates. Price 50 cents.

Astronomy.—(8) Occultations visible in the United States during the year 1848. Computed under the direction of the Smithsonian Institution. By John Downes. 1848. 4°, pp. 12.

(9) Occultations visible in the United States during the year 1849. Computed under the direction and at the expense of the Smithsonian Institution. By John Downes. 1848. 4°, pp. 24.

(10) Occultations visible in the United States during the year 1850. Computed by John Downes, at the expense of the fund appropriated by Congress for a Nautical Almanac, and published by the Smithsonian Institution. 1849. 4°, pp. 26.

* For sale by Geo. P. Putnam & Co., New York, and other Booksellers

(11) Occultations visible in the United States during the year 1851. Computed by John Downes, at the expense of the fund appropriated by Congress for the establishment of a nautical almanac, and published by the Smithsonian Institution. Oct., 1850. 4°, pp. 26. Price 50 cents.

(29) Occultations visible in the United States during the year 1852. Computed by John Downes, at the expense of the fund appropriated by Congress for the establishment of a nautical almanac, and published by the Smithsonian Institution. 1852. 4°, pp. 34. Price 20 cents.

(54) Occultations of Planets and Stars by the Moon during the year 1853. Computed by John Downes, at the expense of the fund appropriated by Congress for the establishment of a nautical almanac, and published by the Smithsonian Institution. 1853. 4°, pp. 36. Price 20 cents.

(3) Researches relative to the Planet Neptune. By Sears C. Walker, Esq. 1850. 4°, pp. 60. Price 30 cents.

(4) Ephemeris of Neptune for the opposition of 1848. By Sears C. Walker, Esq. 1849. 4°, pp. 8.

(4*) Ephemeris of the Planet Neptune for the date of the Lalande observations of May 8 and 10, 1795, and for the oppositions of 1846, '47, '48 and '49. By Sears C. Walker, Esq. April, 1849. 4°, pp. 32. Price 20 cents.

(6) Ephemeris of the Planet Neptune for the year 1850. By Sears C. Walker, Esq. April, 1850. 4°, pp. 10. Price 10 cents.

(7) Ephemeris of the Planet Neptune for the year 1851. By Sears C. Walker, Esq. Dec., 1850. 4°, pp. 10. Price 10 cents.

(24) Ephemeris of the Planet Neptune for the year 1852. By Sears C. Walker, Esq. 1853. 4°, pp. 10. Price 10 cents.

(79) New tables for determining the values of the coefficients in the perturbative functions of planetary motion, which depend upon the ratio of the mean distances. By John D. Runkle, Assistant in the office of the American Ephemeris and Nautical Almanac. November, 1856. 4°, pp. 64. Price 50 cents.

(18) On the history of the discovery of the Planet Neptune. By B. A. Gould, Jr. 1850. 8°, pp. 56. Price 25 cts.

Meteorology.—(52) On the winds of the northern hemisphere. By Prof. J. H. Coffin. Nov., 1853. 4°, pp. 200, and 13 plates. Price $2.

(59) Account of a tornado near New Harmony, Indiana, April 30, 1852, with a map of the track, diagrams and illustrative sketches. By John Chappelsmith. April, 1855. 4°, pp. 12, one map and one plate. Price 30 cents.

(81) On the recent secular period of the Aurora Borealis. By Denison Olmsted, LL.D., Professor of Natural Philosophy and Astronomy in Yale College. May, 1856. 4°, pp. 52. Price 50 cents.

(84) Record of Auroral Phenomena observed in the higher northern latitudes. Compiled by Peter Force. July, 1856. 4°, pp. 122. Price 75 cents.

(83) On the relative intensity of the heat and light of the sun upon different latitudes of the earth. By L. W. Meech. November, 1856. 4°, pp. 58, and 6 plates. Price 75 cents.

(19) Directions for meteorological observations, intended for the first class of observers. By Arnold Guyot. 1850. 8°, pp. 40.

(31) A collection of meteorological tables, with other tables useful in practical meteorology. Prepared by order of the Smithsonian Institution, by Arnold Guyot. 1852. 8°, pp. 212. Price $1,25. (A new edition in press.)

(87) Psychrometrical table for determining the force of aqueous vapor, and the relative humidity of the atmosphere from indications of the wet and the dry bulb thermometer Fahrenheit. By James H. Coffin, A.M. 1856. 8°, pp. 20. Price 10 cents.

(93) Smithsonian meteorological observations for 1855. (In press.)

Chemistry and Technology.—(17) Memoir on the explosiveness of nitre, with a view to elucidate its agency in the tremendous explosion of July, 1845, in New York. By Robert Hare, M.D. 1850. 4°, pp. 20. Price 6¼ cents.

(27) On recent improvements in the chemical art. By Prof. James C. Booth and Campbell Morfitt. 1852. 8°, pp. 216. Price 75 cents.

(88) Researches on the Ammonia-cobalt Bases. By Wolcott Gibbs and Frederick Aug. Genth. (In press.)

Geography, Ethnology and Philology.—(13) Contributions to the physical geography of the United States. Part I.—On the Physical Geography of the Mississippi valley, with suggestions for the Improvement of the navigation of the Ohio and other rivers. By Charles Ellet, Jr., Civil Engineer. 1850. 4°, pp. 64, and one plate. Price 25 cents.

(1) Ancient monuments of the Mississippi valley, comprising the results of extensive original surveys and explorations. By E. G. Squier, A.M., and E. H. Davis, M.D. 1848. 4°, pp. 346, 48 plates and 207 woodcuts. This volume is not on sale by the Smithsonian Institution. It can be had of Geo. P. Putnam & Co., on account of the authors.

(15) Aboriginal monuments of the State of New York, comprising the results of original surveys and explorations; with an illustrative appendix. By E. G. Squier, A.M. 1850. 4°, pp. 188, 14 plates and 72 woodcuts. Price $1,75.

(34) Description of ancient works in Ohio. By Charles Whittlesey. 1851. 4°, pp. 20, and 7 plates. Price 40 cents.

(70) The antiquities of Wisconsin, as surveyed and described by I. A. Lapham, Civil Engineer, &c., on behalf of the American Antiquarian Society. May, 1855. 4°, pp. 108, and 50 plates. Price $4.

(71) Archæology of the United States, or sketches historical and bibliographical of the progress of information and opinion respecting vestiges of antiquity in the United States. By Samuel F. Haven. July, 1856. 4°, pp. 172. Price $1,50.

(86) Observations on Mexican history and archæology, with a special notice of Zapotec remains as delineated in Mr. J. G. Sawkins' drawings of Mitla, &c. By Brantz Mayer. November, 1856. 4°, pp. 36, woodcuts, and four plates. Price 50 cents.

(12) On the vocal sounds of Laura Bridgeman, the blind deaf mute at Boston; compared with the elements of phonetic language. By Francis Lieber. 1850. 4°, pp. 32, and one plate. Price 20 cents.

(40) A grammar and dictionary of the Dakota language. Collected by the members of the Dakota Mission, edited by Rev. S. R. Riggs, A.M.,

Missionary of the Am. Board Com. for Foreign Missions. 1852. 4to, pp. 414. Price $5.

(68) Vocabulary of the Jargon or Trade Language of Oregon. By Dr. B. Rush Mitchell, U. S. Navy, with additions by Prof. W. W. Turner. 1853. 8°, pp. 22. Price 10 cents.

(53) Catalogue of portraits of North American Indians, with sketches of scenery, etc. Painted by J. M. Stanley. Deposited with the Smithsonian Institution. December, 1852. 8°, pp. 76. Price 25 cents.

Microscopical Science.—(20) Microscopical examination of soundings made by the Coast Survey, off the Atlantic coast of the United States. By Prof. J. W. Bailey. Jan., 1851. 4°, pp. 16, and one plate. Price 15 cents.

(23) Microscopical observations made in South Carolina, Georgia and Florida. By Prof. J. W. Bailey. 1851. 4°, pp. 48, and 3 plates. Price 38 cents.

(63) Notes on new species and localities of microscropical organisms. By Prof. J. W. Bailey. Feb., 1854. 4°, pp. 16, and one plate. Price 20 cents.

(44) A flora and fauna within living animals. By Joseph Leidy, M.D. April, 1853. 4°, pp. 68, and 10 plates. Price $1.

Zoology and Physiology.—(16) The classification of Insects from embryological data. By Prof. Louis Agassiz, 1850. 4°, pp. 28, and one plate. Price 35 cents.

(62) Catalogue of the described Coleoptera of the United States. By Frederick Ernst Melsheimer, M.D. Revised by S. S. Haldeman and J. L. Le Conte. July, 1853, 8°, pp. 174. Price $1.

(50) Synopsis of the marine Invertebrata of Grand Manan, or, the region about the mouth of the Bay of Fundy, New Brunswick. By W. Stimpson. March, 1853, 4°, pp. 68 and 3 plates. Price 75 cents.

(30) Contributions to the natural history of the fresh water fishes of North America. By Charles Girard. I.—A monograph of the Cottoids. Dec., 1851. 4°, pp. 80, and 3 plates. Price 75 cents.

(45) Anatomy of the nervous system of *Rana pipiens*, L. By Jeffries Wyman, M.D. March 1853. 4°, pp. 52, and 2 plates. Price 50 cents.

(82) Researches chemical and physiological, concerning certain North American Vertebrata. By Joseph Jones, M.D. July, 1856. 4°, pp. 150, and 27 woodcuts. Price $1,50.

(89) North American Oology, or descriptions and figures of the eggs of North American Birds, with notices of their geographical distribution during the breeding season. By Thomas M. Brewer, M.D. Part I. Rapacious birds. (In press.)

(49) Catalogue of North American Reptiles, in the museum of the Smithsonian Institution. Part I.—Serpents. By S. F. Baird and C. Girard. January, 1853. 8°, pp. 172. Price 75 cents.

Botany.—(22) Plantæ Wrightianæ Texano-Neo-Mexicanæ. By Asa Gray, M.D. Part I. March, 1852. 4°, pp. 146, and 10 plates. Price $2,50.

(41) Plantæ Wrightianæ Texano-Neo-Mexicanæ. Part II. An account of a collection of plants made by Chas. Wright, in Western Texas, New

Mexico, and Sonora, in the years 1851 and 1852. By Asa Gray, M.D. Feb. 1853. 4°, pp. 120, and 4 plates. Price $1,25.

(32) Nereis Boreali-Americana, or contributions to a history of the marine Algæ of North America. Part I. Melanospermeæ. By William Henry Harvey, M.D., M.R.I.A. Jan. 1852. 4°, pp. 152, and 12 colored plates. Price $3.

(43) Nereis Boreali-Americana, or contributions to a history of the marine algæ of North America. Part II. Rhodospermeæ. By W. H. Harvey, M.D., M.R.I.A. March, 1853. 4°, pp. 262, and 24 plates, colored. Price $5.

(46) Plantæ Fremontianæ; or, description of plants collected by Col. J. C. Fremont, in California. By John Torrey, F.L.S. 1853. 4°, pp. 24, and 10 plates. Price 50 cents.

(60) Observations on the *Batis maritima* of Linnæus. By John Torrey, F.L.S. 1852. 4°, pp. 8, and one plate. Price 10 cents.

(61) On the *Darlingtonia californica;* a new pitcher plant from Northern California. By John Torrey, F.L.S. 1853. 4°, pp. 8, and one plate. Price 10 cents.

Palæontology.—(14) A memoir on *Mosasaurus*, and the three allied new genera, *Holcodus*, *Conosaurus*, and *Amphorosteus*. By Robert W. Gibbes, M.D. Nov., 1850. 4°, pp. 14, and 3 plates. Price 25 cents.

(41) Memoir upon the extinct species of fossil ox. By Joseph Leidy, M.D. Dec., 1852. 4°, pp. 20, and 5 plates. Price 25 cents.

(52) The ancient Fauna of Nebraska; or, a description of remains of extinct Mammalia and Chelonia from the Mauvaises Terres of Nebraska. By Joseph Leidy, M.D. June, 1853. 4°, pp. 124, and 25 plates. Price $2.

(72) A memoir on the extinct sloth tribe of North America. By Joseph Leidy, M.D., Professor of Anatomy in the University of Pennsylvania, and Curator of the Academy of Natural Sciences of Philadelphia. June, 1855. 4°, pp. 70, and sixteen plates. Price $2.

(*Concluded in our next.*)

Gustav Bischof: Elements of Chemical and Physical Geology, Vol. II. Translated by B. H. Paul. Cavendish Society.

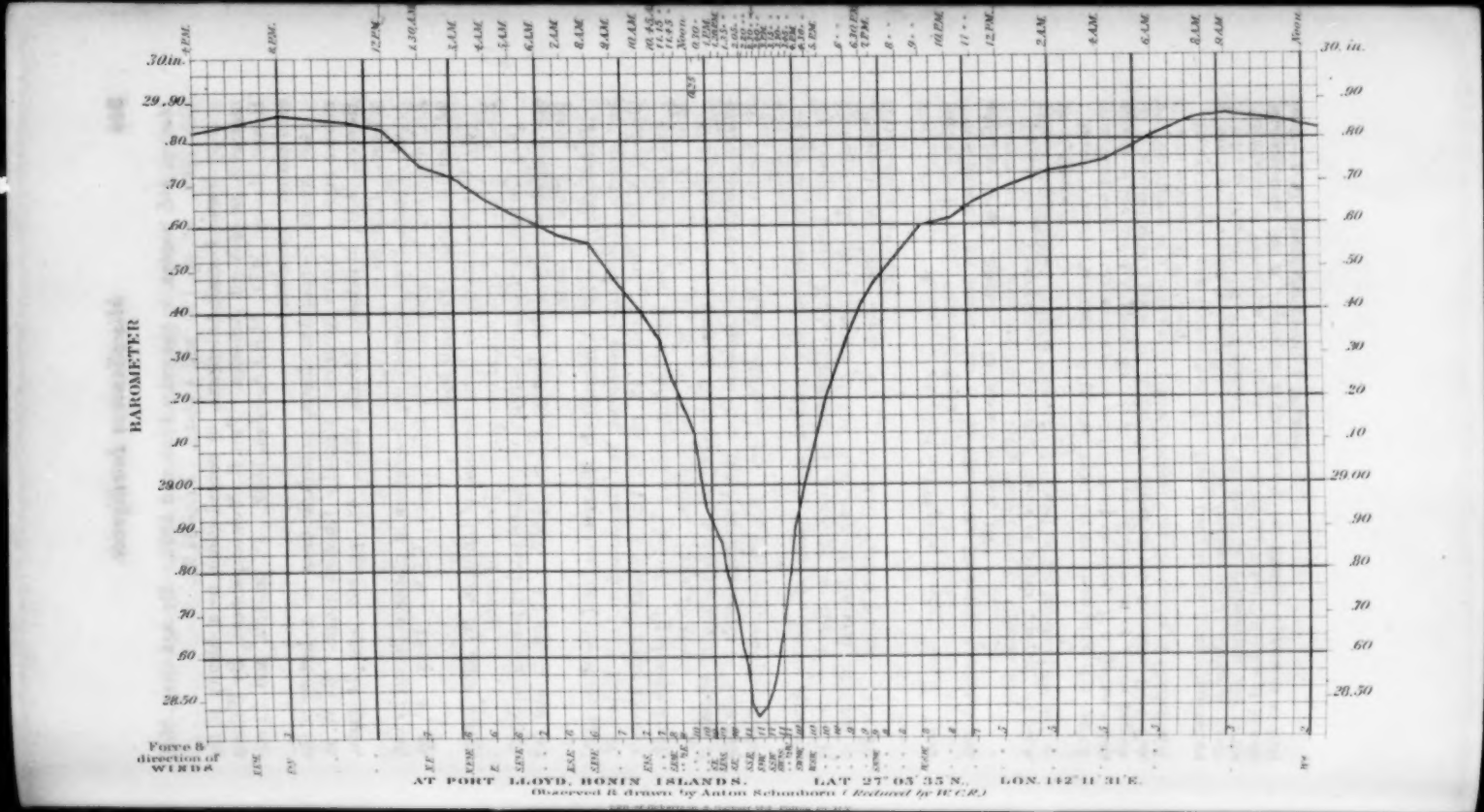
T. Scheerer: An Introduction to the Use of the Blowpipe; translated, with additions, by H. T. Blanford. Leipsic and London, 1856.

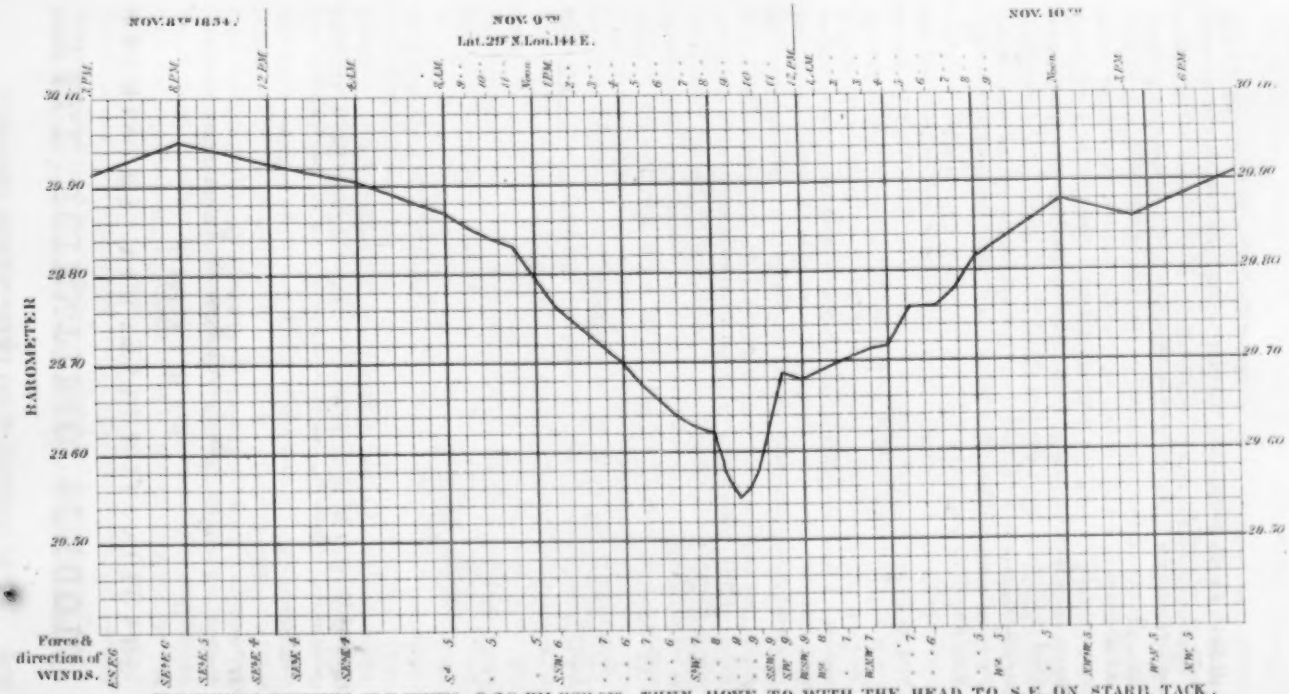
Liebig and Kopp: Jahresbericht for 1855, Parts 1 and 2. Giessen, 1856.

Thomas Say: Descriptions of Terrestrial Shells of North America. 44 pages, 12mo. Philadelphia: Childs & Peterson. A reprint of the papers of Mr. Say, by W. G. Binney.

Elliot Society, Charleston, S. C., Jan., 1856.—p. 29, Description of a new Ostræa found living in the waters of the coast of South Carolina; *F. S. Holmes.*—Monograph of the genus Cryptopodia; *L. R. Gibbes.*—Description of a new Baptisia (B. stipulacea), with a plate; *W. H. Ravenel.*—Notes on the American Devil Fish, with description of a new genus (Diabolichthys) from the harbor of Charleston, S. C., with a plate; *F. S. Holmes.*

Proceedings of the Boston Soc. Nat. Hist., Dec., 1856.—p. 33, Observations on the North Carolina or Deep River coal; *C. T. Jackson.*—p. 34, Cause of change of color in birds, etc.; *D. F. Weinland.*—p. 37, Note on Petromyzon, and in the classification of Vertebrata; *L. Agassiz.*—p. 40, on the Fossil Trilobites of Eastern Massachusetts; *W. B. Rogers, C. T. Jackson.*—p. 44, Electric apparatus of *Raia lævis.*—p. 47, Young Gar-Pikes; *L. Agassiz.*


BAROMETER
30in.
29.90
.80
.70
.60
.50
.40
.30
.20
.10
29.00
.90
.80
.70
.60
28.50
30. in.
.90
.80
.70
.60
.50
.40
.30
.20
.10
29.00
.90
.80
.70
.60
.50
20.50
Force & direction of WINDS
AT PORT LLOYD, BONIN ISLANDS. LAT 27°05'35 N. LON. 142°11'31'E.
(Observed & drawn by Anton Schonborn / Reduced by W.C.R.)



VINCENNES RUNNING N° E. UNTIL 8 20 PM. NOV. 9TH THEN HOVE TO WITH THE HEAD TO S.E., ON STARB. TACK.

Observed & drawn by Anton Schonborn *(Reduced by W.C.R.)*

Lith. of Sherman & Smith 93 Fulton St. N.Y.